Adaptive **A**utomation in **A**ssembly **For BLUE** collar workers satisfaction in **E**volvable context

GA number: 723828

Deliverable D7.5

Market Analysis Report - Initial version

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Executive summary

A4BLUE project proposes the development and evaluation of a new generation of sustainable, adaptive workplaces dealing with the evolving requirements of manufacturing processes, and the introduction of automation mechanisms that are suitable for flexible and efficient task execution in interaction with human workers by optimizing human variability through personalized and context aware assistance capabilities as well as advanced human-machine interfaces.

Although the project is instantiated in two real industrial scenarios from the aerospace sector, AIRBUS and CESA, the concepts, methodologies and proposed solutions can be considered suitable for other processes and sectors such as top class automotive, electric vehicles, shipbuilding, wind power, capital goods (machine tool, engines, compressors, etc.) where the problematic is similar: *assembly of big complex products with low scale production and several manual operations due to the high flexibility requirements*.

In task "**T7.4. Market and socio-economic impact analysis",** all the consortium members are committed to integrate the knowledge and results generated in the A4BLUE project with market needs. The aims of this task**,** which will continue till the M30, are indeed i) the monitoring of the technological achievements following a business case approach on the two industrial use cases developed during the project and ii) the preparation of a market and a socio-economic analysis.

Within this 1 year project, the following activities were carried out:

- A **relevant innovation management process** was defined to be implemented till M30 in collaboration with all the partners.
- **2 industrial use cases** at AIRBUS and CESA were defined within WP1 – Task T1.2 "Use case scenarios definition"
- The **preliminary market analysis:** an overview and market trends of the sectors where there is small scale production of complex products\parts is reported.
- the **initial socio-economic impact analysis**, based on the preliminary results and activities of Tasks "T7.1 Value Chains Stakeholders Analysis", "T7.2 Dissemination, Communication and Exploitation Plan", "T1.1 Multi-dimensional perspective requirements", "T3.2 Model for the Assessment of Worker Satisfaction", "T3.3 Methodology for assessment of usability".
- The **check of the compliance with regulations and standards** for the further take off of the project results, based on the safety risk assessment related standards from Tasks "T4.2 Safety risk management", "T7.3 Standardization activities" and "T1.1 Multi-dimensional perspective requirements".

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Abbreviations

APAC	Asia-Pacific
CMMS	Computerized Maintenance Management System
CoIN	Collaborative Innovation Network
CAGR	Compound annual growth rate
ECB	European Central Bank
EFFRA	European Factories of the Future Research Association
EMEA	Europe, the Middle East and Africa
ERP	Enterprise resource planning
EV	Electric Vehicle
FoF	Factory of the Future
GCC	Gulf Cooperation Council region
GDP	Gross Domestic Product
HSE	Health and Safety Executive
ICE	internal combustion engine
IoT	Internet of Thing
M&A	Mergers and acquisitions
MES	Manufacturing Execution System
NAFTA	North American Free Trade Agreement
PA	public administration
QMS	Quality Management System
R&D	Research & Development
R&I	Research & Innovation
RPK	Revenue passenger kilometers
SaaS	Software as a Service
SUV	Sport Utility Vehicle

V2G	Vehicle to grid
VHS	Very High Speed
VR\AR	Virtual reality\Augmented reality
WP	Work Package

Glossary of terms

Augmented Reality (AR)	Overlying visualization of helpful information, instructions, animations or restrictions regarding workflow, required tools, assembly parameters and required feedback for blue-collar workers in worker's primary field of vision, interacting with worker's current actions and environment.
Payware software	Commercial software or payware, is computer software that is produced for sale or that serves commercial purposes. Commercial software can be proprietary software or free and open source software.
Stakeholder	Those actors who will not interact directly with the future A4BLUE solution, but are involved in the process as for example the supervisors.
Industry	It refers to the manufacturing sector (i.e. industries providing added value through the transformation of materials into products) and excludes mining, construction and energy

1 INTRODUCTION

1.1 CONTEXT AND SCOPE OF THIS DELIVERABLE

Deliverable D7.5 is the output of the **Task 7.4 "Market and socio-economic impact analysis".** Within T7.4 the monitoring of the technological achievements following a business case approach on the industrial use cases developed during the project will be carried on.

Within this 1 year project, the following activities were carried out:

- A **relevant innovation management methodology** was defined to be implemented till M30 in collaboration with all the partners.
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This initial analysis supports the realization of an effective exploitation plan within Task "T7.2 Dissemination and communication strategy", maximizing the chances of successful replication of A4BLUE results outside the specific sectors addressed during the project.

1.2 RELATIONSHIP WITH OTHER TASKS

Based on the definition of the innovation management process, **Task 7.4 "Market and socio-economic impact analysis"** will receive relevant inputs from other tasks:

- "T1.2 Use case scenarios definition", "T7.1 Value Chains Stakeholders Analysis", "T7.3 Standardization activities", "T4.2 Safety risk management" for the market analysis and the compliance with regulations and standards.
- "T1.1 Multi-dimensional perspective requirements", "T3.2 Model for the Assessment of Worker Satisfaction", "T3.3 Methodology for assessment of usability" for the socio-economic impact analysis.

On the other hand, T7.4 is the input for the "T7.2 Dissemination and communication strategy", enabling the development and implementation of the A4BLUE exploitation strategy.

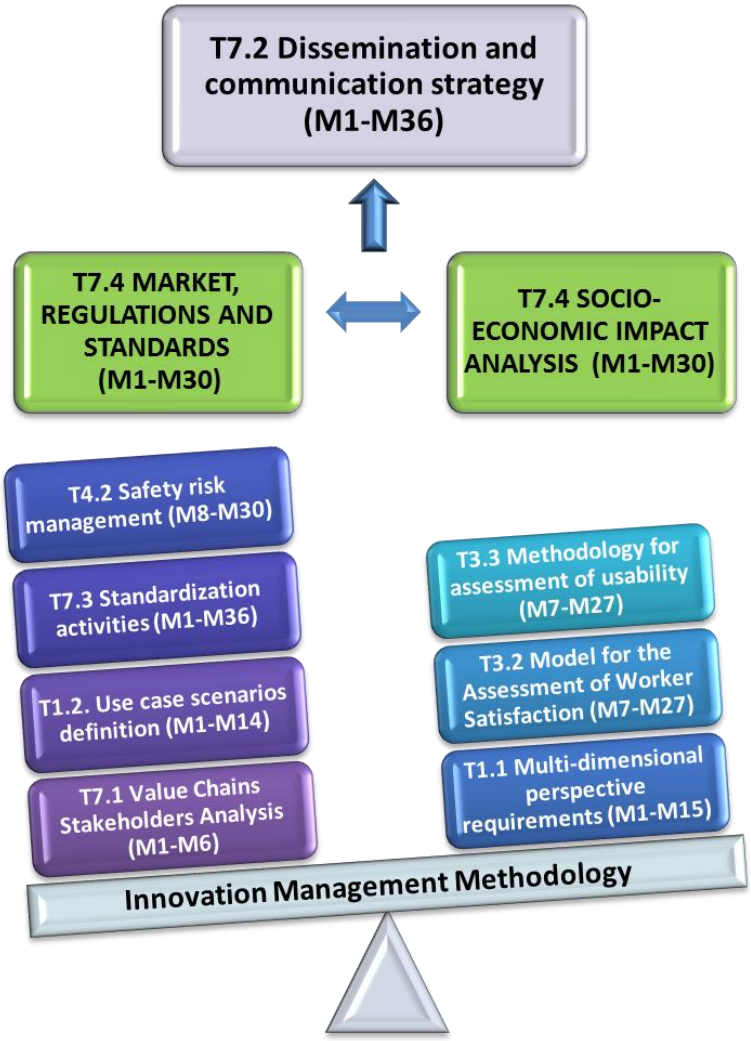


Figure 1 Relationship with other tasks

1.3 DOCUMENT STRUCTURE

The document is composed by these main parts:

- **Introduction**, about the context and scope of this deliverable and the relationship with other tasks.
- Chapter 2 describes the methodology applied based on the **innovation management process** adopted by A4BLUE.
- Chapter 3 resumes the **industrial scenarios**.
- Chapter 4 provides an overview of the **market sectors** under investigation.
- Chapter 5 describes the **socio-economic impacts**.
- Chapter 6 describes the compliance with **regulations and standards**.
- **Conclusion highlights.**
- **References** section.

2 INNOVATION MANAGEMENT METHODOLOGY

The mission of the Innovation management methodology is to actively sustain the A4BLUE project activities and results well beyond the end of the project itself, and to get the entire consortium involved in such activities. The vision of the project is to improve factory automation not only from a technical/technological point of view, but also relating to workers' satisfaction and needs. To this end the Innovation management methodology has to copy with technological, ethical, financial, economic and cognitive issues that inevitably have to be turned into challenges.

Many successful innovative organisations from start-ups to large established firms often have one thing in common - they are good at managing change to achieve sustainable competitive advantages in the form of new products and services or the way the organisation operates. Innovation thus plays a key part in the formation, development and growth of firms and innovation can involve combing knowledge from different parts of the world. The Innovation Management equips the partners with the knowledge and skills to manage innovation in today's rapidly evolving global marketplace.

The A4BLUE Innovation Management Methodology starts by providing partners with an understanding of the sources, process and strategy of technological innovation. Specifically, collaboration is an important source of innovation: **to this end the A4BLUE partners can be seen as a Collaborative Innovation Network** (**CoIN**) [1], which guarantees internal transparency and direct communication. In fact members of a CoIN:

- Collaborate and share knowledge directly with each other within self-organizing virtual teams, through the email, chat, social networks.
- Come together with a shared vision because they are intrinsically motivated to do so within the A4BLUE project and seek to collaborate in some way to advance in innovation.
- Might open up the CoIN to external stakeholders.

Indeed, CoIN is a type of open collaboration that helps partners to become more creative, productive and efficient within the A4BLUE project. By adopting CoIN as part of their culture, partners can accelerate innovation, uncover hidden business opportunities and enhance synergies. Partners will not only engage their internal resources but also external stakeholders.

A4BLUE CoIN presents these main characteristics:

- **EU wide partnership**: technology allows members of the consortium to collaborate from different EU countries.
- **Interdependent** cooperation between members in different Tasks and WPs is a key factor to achieve common goal.
- **There is no superior command** since all partners have the same level of involvement.
- **Collaborative work towards a common goal**: members are willing to contribute, work and share freely. They are intrinsically motivated to create and share knowledge in favor of the project common goal.
- **Dependence on trust**: cooperative behavior and mutual trust is needed to work efficiently within the network.

All the members of A4BLUE Consortium are involved in some extent to provide support to the CoIN. For example, ENGINEERING adopts, in A4BLUE solution, FIWARE technologies which allow organizations to capture the opportunities that are emerging with the new wave of digitalisation brought by combining the Internet of Things with Context Information Management and Big Data services on the Cloud. The **FIWARE Community** can be indeed considered as a CoIN, since it is an independent open community whose members are committed to materialise the **FIWARE mission**, that is: "**to build an open sustainable ecosystem around public, royalty-free and implementation-**

driven software platform standards that will ease the development of Smart Applications in multiple sectors".

The Open Source Community working on the FIWARE platform - a rich suite of components, called Generic Enablers, which export open standard APIs, typically offered "as a Service" – is formed by **contributors to the technology** and by those who contribute in building the FIWARE ecosystem and making it sustainable over time through the **FIWARE Foundation**.

The FIWARE Foundation is the legal independent body providing shared resources to help achieving the FIWARE mission by promoting, augmenting, protecting, and validating the FIWARE technologies as well as the activities of the FIWARE community, empowering its members including end users, developers and rest of stakeholders in the entire ecosystem. Objectives of the FIWARE foundation are to empower:

- **Developers,** to bring best-of-breed tools to write great code, manage the development process and benefit from quality validation processes.
- **Users**, to access software enabling the development of new solutions, making their best use, being able to provide feedback and benefit from large-scale testing facilities.

All these considerations bring to consider FIWARE Community as "a cyber-team of self-motivated people with a collective vision, enabled by the Web to collaborate in achieving a common goal by sharing ideas, information, and work" that is the CoIN definition by the originator of the term, Peter Gloor from MIT Sloan's Center for Collective Intelligence. Furthermore, CoIN definition fits well with the working principles of an innovative team like the one of an open source software developers' community:

- Open source software developers contribute their code because they expect their co-developers to do the same, so that everybody might enjoy the benefits of sharing the software code (Reciprocity);
- The skills and the role of every programmer are obvious to all members working on a common open source software project. All team members expect to get fair credit for their contributions, as getting recognized by peers is one of the main motivations for CoIN participants (Transparency);
- Open source developers are expected to stick to the programming rules and guidelines that are in effect for their project (Consistency); in an open source software project, it is expected that roles will be filled strictly on the basis of merit, and not because of previous relationship, hierarchical positions, or other non-project relevant criteria (Meritocracy).

Apart the CoIN, the A4BLUE Innovation Management methodology is influenced by many internal and external factors (see next figure) and requires also **an evaluation of external industry innovation and economic trends** that allow organisations envisaging strategic change and the structures they need to use to foster an internal environment for innovation.

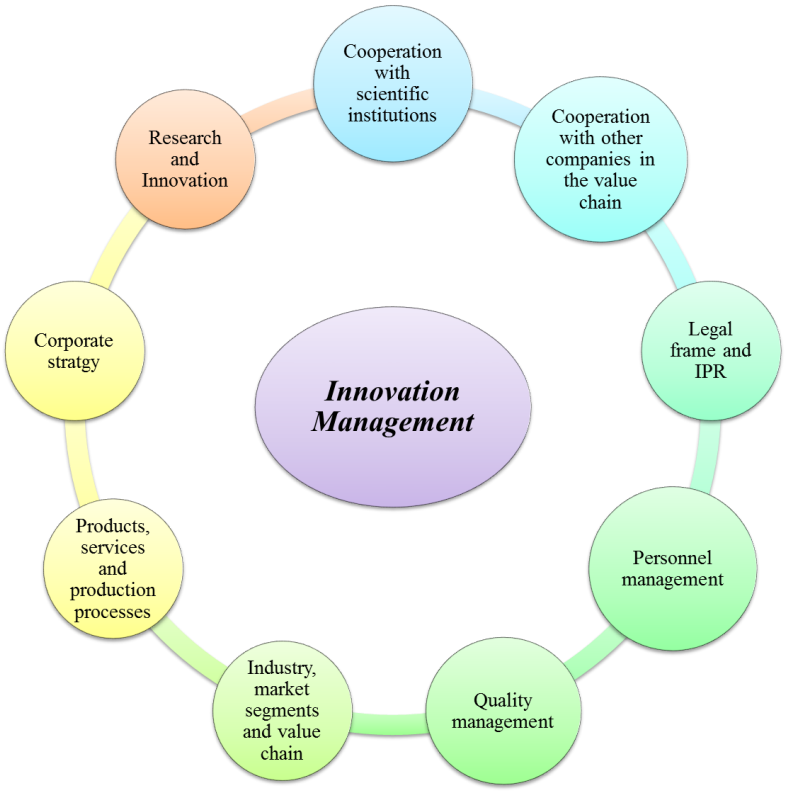


Figure 2 Innovation Management – Influential factors

By applying the proposed methodology, by the end of the A4BLUE project, we will be able to:

- Identify the core areas of technology innovation and understand the internal and external environments that foster the exploitation of the project results.
- In-depth understand the sources, processes and strategies of innovation.
- Analyze the types of market opportunities and scenarios in partners' internal and external environment that enable the exploitation of the project results.
- Explain and analyse industry dynamics in differing markets.
- Critically appraise the nature of innovation and understand the implications for how firms can engage their exploitation strategy.
- Evaluate different business scenarios.

3 A4BLUE INDUSTRIAL SCENARIOS

Two real industrial scenarios involving AIRBUS and CESA were defined within WP1 – Task T1.2 "Use case scenarios definition" and described in details in *"D1.2 Scenarios definition"*: in the next sections their overviews, extracted from the D1.2, are reported to better understand the operative context of the A4BLUE solution within **the aerospace sector**.

3.1 INDUSTRIAL SCENARIO - CESA

With more than 25 years of experience, CESA is the European leader in fluid mechanics equipment. In particular, hydraulic actuators for landing gears are one of the main products manufactured by CESA. This is one of the reasons why the assembly of the retraction actuator for a single aisle aircraft main landing (see figure 2) gear has been selected as CESA use case scenario. The scenario will focus not only in the assembly process itself but in some of the auxiliary operations that are crucial to guarantee a smooth assembly process.

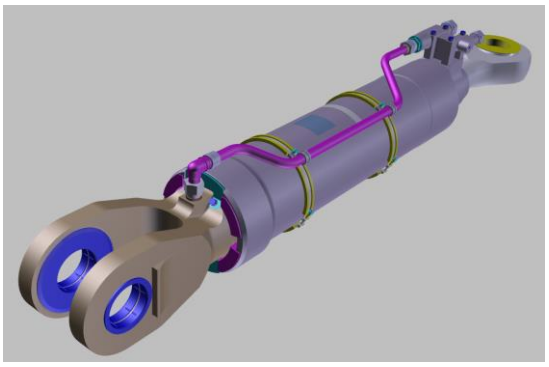


Figure 3 Assembly and auxiliary operation of the main landing gear retraction actuator –Main landing gear extraction actuator

This use case scenario involves two application scenarios aiming at improving two different areas (i.e. the auxiliary deburring process of the parts to be assembled and main landing gear retraction actuator assembly process itself – figure 3).

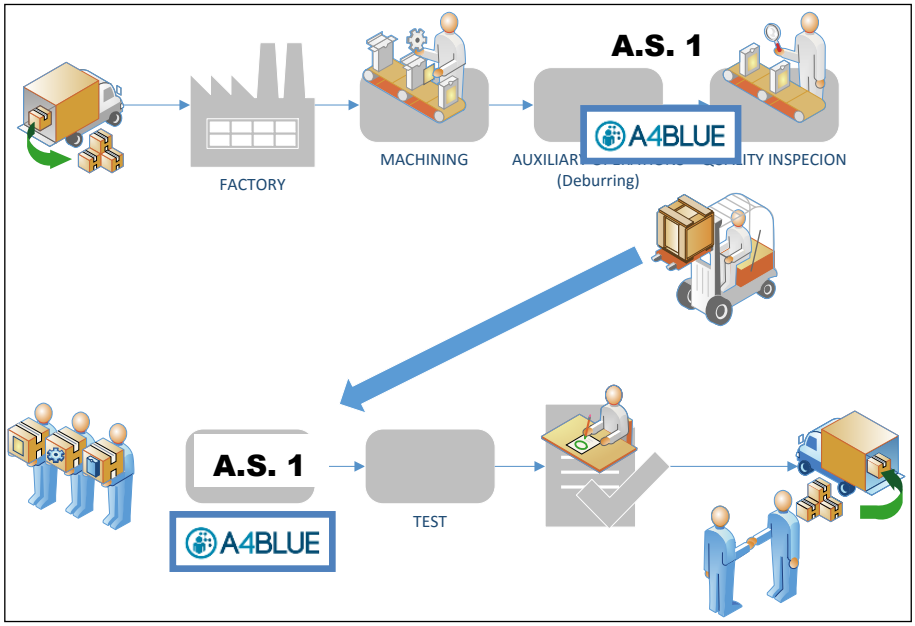


Figure 4 Assembly and auxiliary operation of the main landing gear retraction actuator – Flow Chart Manufacturing and Assembly Process

During the assembly process, it is necessary to perform some auxiliary operations manually (see Figure 5) and this requires a high effort for the operator. To improve this, CESA is planning to incorporate progressively automation mechanisms in the auxiliary operations to increase efficiency, productivity and quality rates within the assembly process, and simultaneously improve the ergonomic conditions of the worker to reduce the hardness of this type of operations.

Figure 5 Assembly and auxiliary operation of the main landing gear retraction actuator - Examples of manual deburring process

On the other hand the developments in the assembly process itself should focus on providing a single and easy interface that offers the operator only the required information for each task of the assembly process. Currently the technical information that is required to perform the process is highly fragmented. The assembly operator needs to navigate through a large number of computer systems, as well as paper based instructions, to find the required documentation to perform the specific operation. This is highly time consuming and makes the task very complex, in particular for not experienced workers. Adapted AR based on the job guidance could be used to provide this required information and allow a faster and easier training as well as support capabilities for sharing the knowledge between the operators.

3.2 INDUSTRIAL SCENARIO - AIRBUS

AIRBUS selected a use case scenario based on the complex hydraulic system assembly, quite manual, paper-based instructions and comprising various sets of operations including a lot of different parts to be installed in constraint positions, due to the Landing Gear Nose Box (LGNB) configuration. The expected improvements should come from the introduction of smart tools that should be automatically calibrated considering the operation being performed and the related standard operating instructions, adapted on the job guidance (i.e. considering both the way the information is displayed to the workers and the AR device to display such information), decision support system to secure a full quality assurance approach by making available the information collected from the smart tools during the assembly process.

The proposed use case scenario is based on the complex hydraulic system assembly, quite manual, paper-based instructions and comprising various sets of operations including a lot of different parts to be installed in constraint positions, due to the Landing Gear Nose Box (LGNB) configuration.

Main operations involved in the assembly process are: pre-installing & pre-tightening marking, screwing, tightening, crimping, protection sealant and varnish applying, glue applying, cleansing, metallization.

In the scope of the A4BLUE project the selected business process to be used for validation is the hydraulic assembly in the Landing Gear Nose Box of the A350, including at least Smart Tools and AR devices.

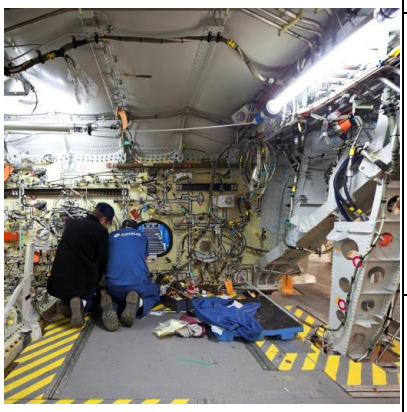
Central box overview	Parts involved in the assembly			
Hydraulic assembly view 	Clamp blocks		Fittings	
	Clamp		Flexible pipes	
	Pipes			

Table 1 Towards a next generation of hydraulic system assembly through Automation and Virtual/Augmented Reality- Parts involved in the assembly

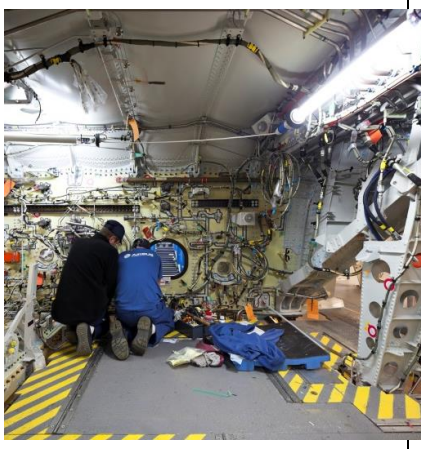
Central box overview	Tools involved in the assembly
	Nutrunner & Screwdriver Wrench: 1 tool = 1 Torque
Hydraulic assembly view 	

Table 2 Towards a next generation of hydraulic system assembly through Automation and Virtual/Augmented Reality- Tools involved in the assembly

4 INITIAL MARKET ANALYSIS

This section covers the market opportunity and should demonstrate that there is a viable market of sufficient size and scale for the A4BLUE product/service solution. Once the market research is done, the market understood, it'll be possible to justify the projections made in the A4BLUE business plan (Task T7.2).

The expected results listed in table 3 will be exploitable **firstly in the manufacturing for the aerospace industry**, driven by the use cases, and then they can be transferred to other segments such as *electric vehicles, top class automotive, wind power, capital goods, shipbuilding, railway*, characterized, on the one hand, by **complex products and small scale production** (i.e. derived from the large number of product variants and/or high customisation degree) that **require high flexibility** and on the other hand by an increasing **pressure to raise productivity rates**. In the mentioned sectors assembly and auxiliary operations (e.g. inspection, maintenance) are mainly performed by humans. **Manual work** has the advantage of being the most **flexible** method to carry out these tasks as people bring inimitable agility to adjust to changes and operate in uncertain environments, to learn from experience, to apply tacit knowledge, to evaluate problems and to find quick solutions.

However manual intensive activities present several drawbacks such as the **difficulty to increase productivity rates; the dependence on highly skilled workers and their training needs**, and the unanticipated production flow fluctuations that can be caused by **human variability**. People bring physical and cognitive skills that cannot be replaced by automation but also physical and cognitive limitations that can impact on system performance and operations.

Furthermore manufacturing systems need to deal with an **ever-changing environment** due to short term changes caused by **human** (e.g. worker's anthropometric, cognitive, and sensorial characteristics, skills, etc.) or **production related variability** (e.g. work orders re-schedule, human resources re-allocation, automation failures, etc.) or long term changes caused by **market`s demands and company's strategy** (e.g. introduction of new products that need new processes and expertise, etc.) and **technology advancements** that can help to allocate more tasks for automation or imply changes to the way workers perform tasks and require the introduction of new skills, or introduce new control systems, etc. Additionally, long term changes will arise as a result of **demographic trends, particularly the forecasted shrinking of the skilled labour force** which will yield a limited access to qualified employees and emphasizes the importance of shifting to a more inclusive human resource approach which **makes the best use of the entire available workforce** (including young people with higher technological skills and low manual/craft expertise; older people with high experience but lower technological literacy and potentially declining capabilities, and workers with some kind of physical or cognitive limitation, etc.).

In this context of ever-changing demands, assembly systems need to **put together humans and automation taking advantage of each other's strengths** (people bring unrivalled adaptability and dexterity whilst automation provides superior consistency and reliability) to **balance flexibility and productivity** requirements in an easy and cost effective way. To achieve this challenge companies need to re-design production systems and implement an **adaptive automation strategy** to **increase adaptability**, **lower efforts for setting up** and **executing** operations, **compensate** workers' **limitations,** and **increase workforce satisfaction** to improve levels of organizational commitment and retention. Generally speaking, the adoption of such strategy is a key factor to **increase productivity** while coping with **flexibility needs**, nevertheless it must be analyzed carefully in order to deal with **both social and economic sustainability**.

The steps followed to analyse the market are hereafter illustrated:

- **Identification of the main market:** the main target market is the **manufacturing industry.**
- **Market Size and Trends:** the total potential value of the market for the A4BLUE solution\service is shown, in all the targeted markets, domestic and international, current and

future. In addition recent changes, future predictions and trends are reported. Demographic changes and socio-economic factors are presented in section 5.

- **Market Structure and Location:** the structure of the market entering and how the opportunity for the A4BLUE service\solution has been created will be understood. In addition we investigated where the main customers (key players) are located.
- **Competitive Positioning and Advantage:** analysis of the competitors solutions in the **manufacturing industry** market, paying particular attention to how they are meeting the customer need: we will answer questions like these:
    - What are the competing products and services?
    - Who supplies them?
    - At what cost?
    - To whom?
    - Advantages and disadvantages of the competitors' offerings – how do they compete? What is their focus? What resources do they have?
- **A4BLUE targeted users:** this is our assessment of why potential customers will choose to buy\adopt A4BLUE product\solution in place of those by competitors. Advantages may include unique features, price, new technologies or systems, better value to customers in terms of efficiency or cost/benefit ratios, greater compatibility with existing systems.
- **Target Market Segments:** the manufacturing market was segmented in sectors characterized, on the one hand, by **complex products** and **small scale production** (i.e. derived from the large number of product variants and/or high customisation degree) that **require high flexibility** and on the other hand by an increasing **pressure to raise productivity rates.** The identified market segments are **aerospace, electric vehicles, top class automotive, wind power, capital goods, shipbuilding, railway sectors**: for each of them the following information were gathered:
    - Size of each market segment
    - Is the segment growing or declining?
    - Characteristics of potential customers in each segment.

4.1 THE MANUFACTURING INDUSTRY: TECHNOLOGIES, STRUCTURE, LOCATION AND FUTURE TRENDS

Europe leads in many manufacturing sectors from automotive to pharmaceuticals and many European players are global leaders in advanced manufacturing and also strong in many innovative high-quality services. Manufacturing in 2050 will look very different from today, and will be virtually unrecognizable from that of 30 years ago (Figure 6).

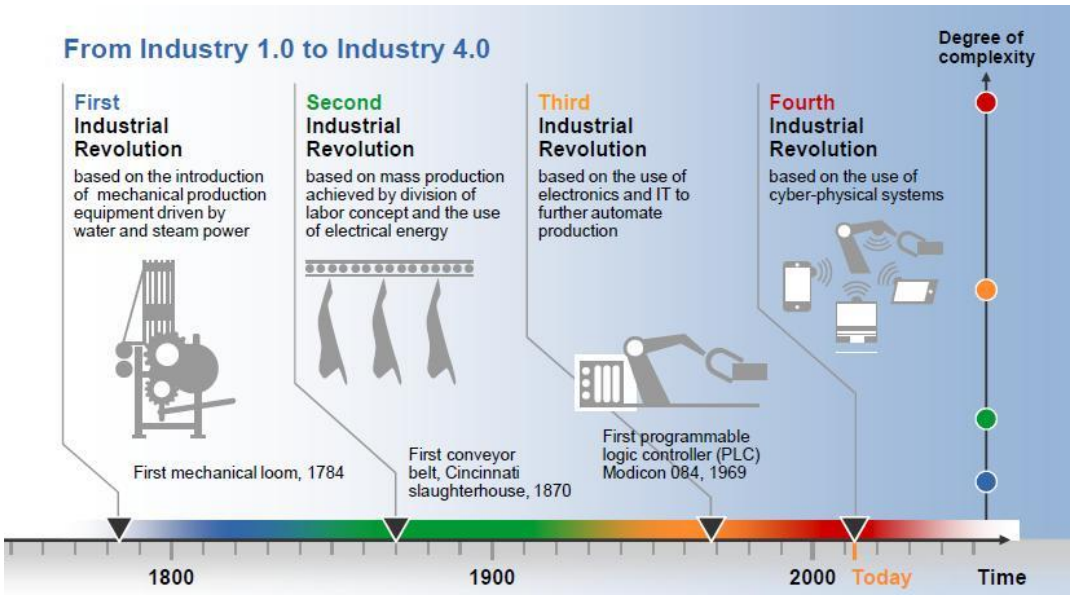


Figure 6 The evolution of the Industry

The evolution of the market during the **2016** has been characterized by a strong growing interest for the so-called "**Industry 4.0**" that is becoming more and more a popular word in the world of industry and include *IoT, Big data & Advance Analytics, Additive manufacturing, Collaborative Robots, Augmented & Virtual Reality* (Figure 7). Describing the context of the manufacturing industry in Europe (especially novel ICT for industry) is a key step for setting the framework in order to perform an in-depth market analysis.

Figure 7 Main topics of Industry 4.0

Based on Eurostat statistics of August 2016 [2], the manufacturing sector includes a vast range of activities and production techniques, from small-scale enterprises using traditional production techniques to very large enterprises sitting atop a high and broad pyramid of parts and components suppliers collectively manufacturing complex products such as aircrafts. Change is inevitable in

manufacturing. The future of manufacturing is often defined by doing more with less, re-ordering the world to create more compact products, and re-aligning enterprise strategies to provide more value.

Europe has been one of front runners in the race to manufacturing excellence. **The manufacturing sector currently accounts for 15.0% of its GDP and provides about 33 million jobs.** However, global transitions such as declining energy prices, diminishing resources, new competition from emerging markets and an aging workforce have resulted in a slower growth trend. Rejuvenation of the existing manufacturing base is Europe's key initiative to continue to boost its industrial growth in an effective, efficient, and sustainable manner.

The manufacturing sector is on the brink of a massive change due to the diffusion of new automated systems being the foundation for creating smart factories. **The market of factory automation and industrial control is expected to reach USD 202.42 Billion by 2020 at a CAGR of 6.73% from 2015 to 2020 [3]**.

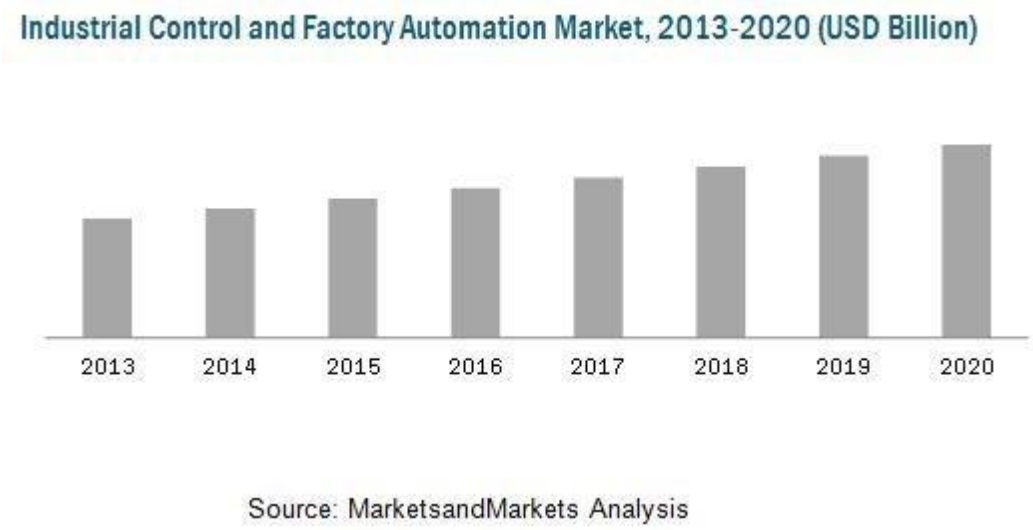


Figure 8 Automation market grow forecast

Factories of the future must be capable to adapt themselves to continuously changing market demand. Therefore new manufacturing technologies are needed: from agile operating machines up to internet based services. In particular, new advanced automation solutions as A4BLUE, that integrate all factory levels in a unique real time framework, are mandatory. Nowadays, neither accepted standards nor assessed development methodologies and software environments are available to support industries when facing such a crucial issue.

A4BLUE is aligned with the **Industry 4.0** vision in terms of:

- **Standardisation and reference architecture**: A4BLUE intends to reach the widest adoption of the new developments in industry by making use of relevant available standards and, whenever relevant, contributing to the development of new ones. Its proposed architecture will contribute to Industry 4.0 reference architecture (T7.3).

- **Managing complex systems:** A4BLUE proposes models, methods and tools to support workers in the control of complex production processes and/or automation mechanisms taking advantage of new technologies as augmented reality and exploiting both the knowledge embedded in the smart factory framework and the workers' tacit knowledge with the aim of helping them to solve unforeseen problems and learn new things (WP5).

- **Safety and security**: A4BLUE will ensure that interactions between the automation mechanisms, informatics and the humans do not pose any potential dangers taking into account existing safety and health at work requirements but also by undertaking bespoke risk assessments of the A4BLUE system itself (WP4). At the same time, A4BLUE will address security issues by including appropriate privacy and data protection mechanisms to safeguard the collected and exchanged data in the system, to prevent against misuse and unauthorized access (WP2). In addition, through the scope of the project the regulatory framework will be monitored so that any emergent changes or requirements of the A4BLUE system are addressed (T7.3).

- **Work organisation and design**: A4BLUE fosters a socio-technological alignment by integrating human participative design activities including the experimental studies for the development of human-machine models.

- **Training and continuing professional development**: A4BLUE proposes the development of personalized assistance tools that will enable lifelong learning by supporting a 'learning by doing' approach and by taking advantage of worker feedback and knowledge in participative work design (WP5).

- **Resource efficiency**: A4BLUE will provide methods and tools to assess the social and economic sustainability of the introduced automations (WP3).

Frost and Sullivan identified some transformative forces in its 2016 research, "Future of Manufacturing in Europe" [4], poised to change European manufacturing (some of them will be supported by A4BLUE activities):

- Factories of the Future: With digitization and ICT infrastructure being core focal points in Europe's 2020 Agenda, the vision of smart and connected factories is swiftly becoming a reality. The €17 billion budget (2014-2020) for the "Industrial Leadership" category in the Horizon 2020 R&D funding program is one such example of how the EU plans to evolve current manufacturing operations by leveraging key areas such as advanced computing, sensor technologies, and robotics. As manufacturers look towards a more connected and collaborative ecosystem, the 5G rollout plan across Europe between EU and Japan (2015-2020) will pave the way for increased connectivity for both fixed and remote assets. The subsequent data deluge will lead to a significant increase in data storage infrastructure, with data stored on the cloud to rise to 40.0% by 2020. Finally, the ability to maximize overall plant efficiency through sensors with bundled functionality, state-of-the art predictive analytics, and control-on-the-go across a diverse array of manufacturing processes will ensure that Europe's industrial production index continues to see an upswing. **A4BLUE is aligned with the Roadmap 2014-2020** [5] and the **European Factories of the Future Research Association (EFFRA) Research Priorities** [6]in terms of:
    - *Economic sustainability of manufacturing challenge*: A4BLUE focuses on the realisation of reconfigurable, adaptive and evolving assembly systems capable of small-scale production in an economically viable way by increasing system performance through cost effective smart and semi-automated manufacturing systems and maintaining high flexibility by enhancing workers' capability and competence through upgradable and reconfigurable automation mechanisms and personalised and context aware assistance tools.
    - *Social sustainability of manufacturing challenge*: A4BLUE will provide methods and tools supported by VR\AR and semantic technologies to exploit both the existing knowledge and knowledge taken up from the workers for training and competence development purposes. Furthermore A4BLUE will achieve safe and attractive workplaces by involving workers and production ergonomics in the design of the

workplace and performing risk analyses for safe human-automation collaboration. Furthermore worker satisfaction criteria will be identified and included in the socio economic assessment of adaptive automation.

- Nearshoring in the East: Central and Eastern Europe are fast-becoming major hubs for manufacturing innovation and value-addition owing to high-quality labor, strong infrastructure, and enhanced R&D support. Poland, Czech Republic, Hungary, Romania and Turkey are growing hotspots for vertical markets such as high-end machine production, electronics manufacturing, automotive manufacturing, food and beverage processing, and pharmaceutical production. Resulting from the advanced digitization of factories, Poland remains the largest and strongest growing economy in Europe, with its advanced manufacturing market growing at 2X when compared to the EU-15 region. The availability of cash grants and tax incentives, the establishment of public-private partnerships, and the availability of skilled researchers are some of the key factors that will continue a manufacturing transition to the East.

- Carbon Neutral Manufacturing: the EU is making significant strides to ensure that member states reduce 40% of their carbon and greenhouse gas emissions by 2025 and 2030, respectively. A key factor to reach this ambitious reduction is that enterprises should ensure that during the rapid reduction of emissions, the temperature rise is maintained well within 2°C. In order to adhere to such a mandate, manufacturers have two viable options: (i) optimize current energy consumption in the plant, or (ii) focus on electricity from renewable sources.

- Human-centered Manufacturing: the pressing need for cost optimization and advancements in ICT is resulting in a decline of low-skilled manufacturing jobs across Europe. While manufacturing employment across EU-28 countries is expected to decline by 4.1% over the next decade, **Europe is expected to undergo a structural shift with a spike in demand for highly skilled work**. Labor productivity is expected to increase by nearly 10.0% and reach EUR 60 thousand/person by 2025 owing to the demand for a highly efficient workforce that has a cross-functional expertise in multiple areas including ICT, simulation, analytics, and virtual reality. The concept of human-centric factories will take center stage and will include the following attributes – (i) dynamic work environments where work profiles will be defined by context, (ii) skill development becomes a core part of operational policy, and (iii) factories aligned to social environments. **A4BLUE will follow the Human Centred Design (or User Centred Design) approach as defined in ISO 13407**: it implies that we need to involve end-users and relevant stakeholders in the definition of the relevant use case scenarios (WP1) and the design (WP2), development (WP3, WP4, WP5) and validation of concepts and use case solutions (WP6) in an interactive and iterative approach starting in early stages of the project and including two validation cycles (i.e. alpha and beta). User participants in the data collection will include **workers**, in order to capture relevant and evolved experience of industrial systems, and also **individuals** from potential end-user groups who will be targeted to improve inclusivity (age, gender, ability, etc.).

- Additive Manufacturing: its entry into the manufacturing domain through applications in consumer electronics, automotive and aerospace, to name a few sectors, is expected to create a €6.3 billion opportunity by 2025.

- Nano-Disruptions: nano-technology is one of the key enabling technologies in Europe's Horizon 2020 plan that could potentially fuel the "Made in Europe" agenda with its extensive R&D funding and support. Traditional industries such as the chemical industries are also poised to benefit from the nano-world with developments in sustainability, energy efficiency, emissions waste, and waste treatment. While the possibilities are plenty, Europe is focused

on taking a safe and integrated approach to nanotechnology. This includes the development of safety laws, information sharing between stakeholders, and monitoring the use of nanomaterials and technologies.

Europe has already started its journey into the realms of the Industrial Internet of Things. With significant support from the European Commission inflows, new strategic partnerships are emerging and technology is moving from being in the lab to being implemented on the plant floor. *The culmination of all the aforementioned transformative forces will help transform Europe into a manufacturing powerhouse over the next decade and further ensure the manufacturing sector accounts for **20.0% of Europe's GDP by 2020 [7]***.

A breakdown by sector shows that only a small number of manufacturing sectors (including pharmaceuticals, food, other transport equipment and other manufacturing) are producing at or before pre crisis levels (Figure 9). However, even in sectors such as **motor vehicles** and beverages, output is close to pre-crisis levels of production following strong growth over the past 12 months. **Capital goods** and intermediate goods industries are more sensitive to business-cycle fluctuations than industries producing non-durable consumer goods and necessity goods such as food, beverages and pharmaceuticals, demand for which is less sensitive to variations in income.

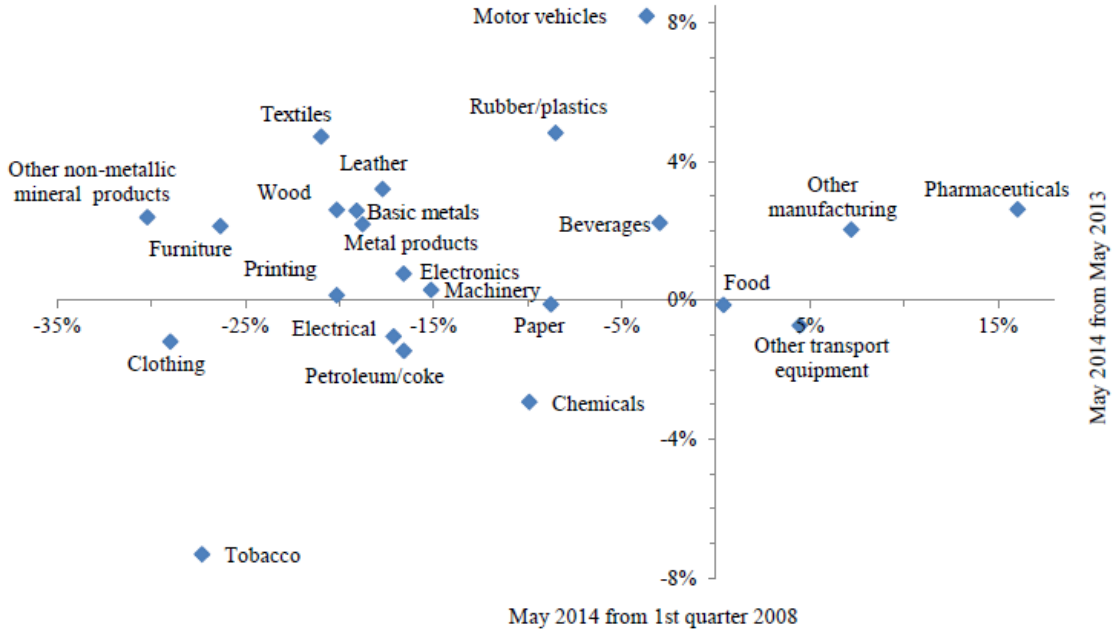


Figure 9 Manufacturing recovery by sector

Despite this context of prolonged crisis, some companies are gaining new markets thanks to R&D investment oriented toward new products, services and emerging technologies. In particular, **investing in digitalization of industrial production line will enable to improve both factory efficiency and workers' safety.**

An exhaustive picture regarding the state of the art of Industry 4.0 in Europe, North America and Asia has been published in a 2015 report by PwC, an investment firm [8]. Industrial leaders are digitizing essential functions within their internal vertical operations processes, as well as with their horizontal partners along the value chain. In addition, they are enhancing their product portfolio with digital functionalities and introducing innovative, data-based services. The 2,000+ companies that were surveyed are expecting to dramatically increase their overall level of digitization. While just 33% rate their company as advanced today, that number jumps to over 70% looking ahead to 2020. At the end of this transformation process, successful industrial companies will become true digital enterprises, with physical products at the core, augmented by digital interfaces and data-based, innovative services. These digital enterprises will work together with customers and suppliers in industrial digital

ecosystems. These developments will fundamentally change individual companies, as well as transform market dynamics across a whole range of industries. And that's true in countries all around the world – in both the developed as well as the emerging markets. Here's what driving change is:

• *Annual digital revenue increases of 2.9%* on average – and a significant minority that expect total increases of more than 50% over five years.

• *Cost reductions of 3.6% p.a.* on average. Digital technologies enable shorter operational lead times, higher asset utilisation and maximum product quality; all told, our survey respondents expect to save US$421 Billion in costs each year for the next five years.

• *Incremental and revolutionary product & service innovation.* To generate these additional revenues, companies will introduce new industrial products with digital features and augment their existing portfolio. Digital services based on data analytics, or even complete digital solutions serving a customer ecosystem, will drive breakthrough revenue growth.

• *A strong commitment to invest.* Industrial sectors are planning to commit US$907 bn p.a. to Industry 4.0 – around 5% of revenue p.a. A major focus of these investments will be on digital technologies like sensors or connectivity devices, and on software and applications like manufacturing execution systems.

In addition, companies are investing in t**raining employees and driving required organisational change**. 55% of the investments expect a payback within two years. Industrial companies need to develop a robust digital culture and to make sure change is driven by clear leadership from the C-suite. They'll also need to attract, retain, and train digital natives and other employees who are comfortable working in a dynamic ecosystem environment.

4.1.1 The role of VR\AR in the manufacturing sector

The companies are looking intensively at innovations that can drive efficacy, efficiency and reduce operational costs.

The A4BLUE solution is the combination and integration between Virtual Reality and Augmented Reality in the manufacturing industries in order to provide support through mobile and/or wearable devices, able to display operating procedures, charts, level gauges and other important information about the actual status of machines and equipment as well as the virtual representation of the real work environment.

There are many usage scenarios where VR\AR apply in the manufacturing sector: Previsualization for assembly/production, Training of Human Resources, Operational Process Optimization, Real Time Assistance to Field Operators executing actions in real time (e.g. maintenance, repair and operation procedures), Risk Management, Team coordination, Outages prevention and management, Dynamic chemical-physical simulation.

In this way the manufacturing industries can reduce downtime, human mistakes and related costs, improving and maximizing the efficiency and efficacy of operational processes, plant maintenance, HSE policies and procedures and final results of operators' training.

In this scenario, with an important role given to VR/AR, there are many economic advantages and the main results are evident on the corporate budget, because these solutions for industrial plants create business value in terms of cost and time savings, allowing a general empowerment.

4.1.2 The role of Human-Centred approach in the manufacturing sector

Differences in skills can be important when trying to explain differences in competitiveness or growth. Since human capital does not readily adjust — geographically or between sectors — to changing demand for labour, and because skills take a long time to build up, including through retraining when

necessary, it is easy to see how mismatches can arise between available and required skills. Such mismatches, whether at firm, sector or economy level, are crucial to success and competitive performance; avoiding or minimising skills mismatches inevitably gives the firm, sector or economy a competitive advantage over rivals and puts it in a stronger position to gain market shares [9].

Analysing the importance of skills to competitiveness is complicated, however, by their very nature: skills are not directly observable and can be hard to measure, even indirectly. Any analysis of skills supply typically relies on proxy variables. For instance [10]where EU Labour Force Survey (LFS) data on educational attainment were broken down by sector, found that the manufacturing sector with the highest proportion of tertiary-educated employees was pharmaceutical products and preparations, followed by coke and refined petroleum products, and computer, electronic and optical products. This result is entirely in line with Eurostat's aggregations of knowledge-intensive activities [11]. The manufacturing sectors with the smallest proportions of tertiary-educated employees were leather and related products, clothing, wood and wood products.

Educational attainment is used as a proxy for skills also by Timmer et al. (2014) [12], who use input-output tables to calculate the factor shares of capital and low-skilled, medium-skilled and high-skilled labour in 560 identified global value chains across 40 countries (including all Member States but Croatia, Figure 10). One of the results obtained is that between 1995 and 2008, the share of high-skilled labour in the value added of the global value chains increased in all EU- 27 Member States except Estonia. The lowest shares of high-skilled labour were in Bulgaria, Romania and Slovakia, where it rose from around 5% in 1995 to around 7% in 2008. The highest shares were in France, the UK, Finland and Germany, rising from around 20% in 1995 to around 25% in 2008. In the 26 Member States with rising shares of high skilled labour, the increase was often at the expense of low-skilled labour (except for the Czech Republic, Latvia and Romania, where both factor shares went up). In some Member States, the share of capital or medium-skilled labour decreased when the share of high-skilled labour went up.

Figure 10 Shares of high skilled labour (ISCED 5 and 6, i.e. stages of tertiary education), 1995-2008. Source Timmer et al. (2014)

However, educational attainment is a far from perfect proxy for skills because it does not take account of the often significant time that has elapsed since primary, secondary or tertiary education was attained; it does not reflect the accumulation of skills and experience by means of additional training, learning and development over time; and it does not take into account the relevance of the education attained to the activities of the firm, sector and economy concerned.

An alternative approach, though not without shortcomings of its own, is to use survey results to assess adult skills. They can be more useful than educational attainment data, for the three reasons mentioned above. Almost 44,000 workers in 34 European countries (including all Member States) were interviewed, with results broken down by 33 aggregated sectors, including five manufacturing sectors (textiles and clothing, chemical industry, metal industry, the agro food industry, and furniture) and construction. Looking specifically at the proportion of surveyed industry workers in each Member State who responded either that they needed further training to cope well with their duties or that they had the skills to cope with more demanding duties, Figure 11, reveals that the perceived mismatch was high in Romania, Greece, Latvia and Cyprus, where it was felt by more than half the respondents, and low in Portugal, Finland and Bulgaria. Across all Member States, 58% of all surveyed industry workers responded that their skills corresponded well to their duties, a higher figure than for services (54%).

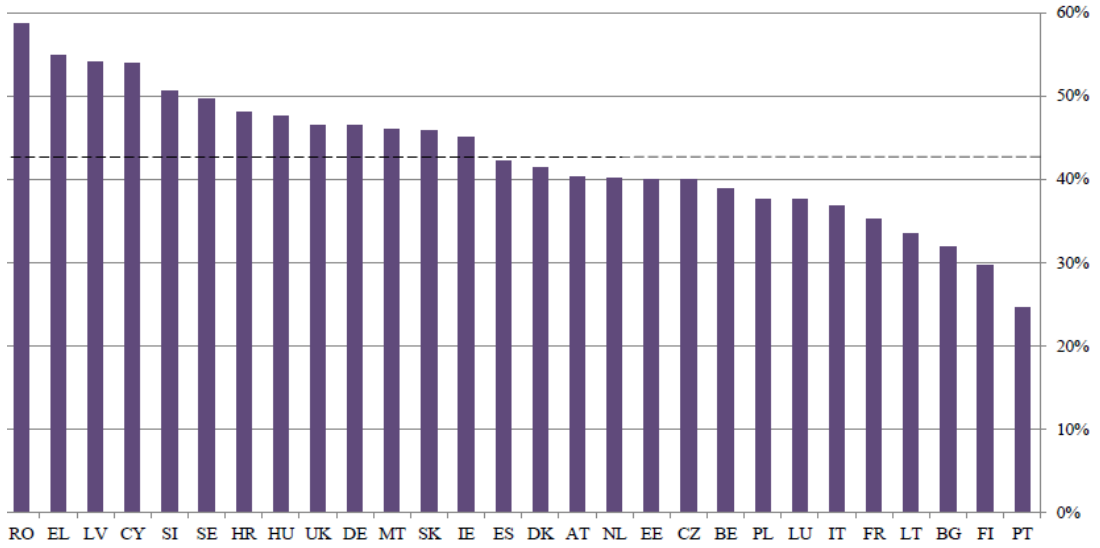


Figure 11 Perceived mismatch between skills and duties: share of surveyed industry workers, 2010

The manufacturing industry's traditional needs for analysis and identification of workforce skills is, however, going to change as a result of technological and process changes. Increasing market demand for smaller batch production and product change, coupled with advancing technological capabilities that make systems more adaptive and reconfigurable, mean that human skill requirements are going to be less specialised. A fundamental concept of the A4BLUE project is to build on this inevitable change in skills requirement and develop new work systems that can accommodate human variability in skills and preferences. Thus, A4BLUE is not focusing on analysis of human skills (and mismatches) but on the human-centred design of systems which will be suitable across skill levels and types.

To this end, the A4BLUE project started out by undertaking a broad analysis of overall requirements that involved analysis at the high level (legal frameworks and standards) to cover the technical specifications that are necessary but also, importantly, at the user level (users and stakeholders within the organisation) to ensure a human-centred approach. In this way the project does not simply focus on operator skills requirements in the traditional way, but on understanding the most important design requirements for future adaptive systems, regardless of skill.

Analysis at the user level was achieved via a generic 'user requirements survey'. This was developed to gather stakeholder views on expected design requirements for future adaptive work systems and to analyse the responses to determine design priorities. The survey covered a wide range of design features and advanced digital manufacturing technologies and was distributed across a wide range of stakeholders in project partner organisations (i.e. across job role types and organisational levels) to ensure breadth and inclusivity.

The survey results showed general support for developing adaptive and inclusive systems that comprise novel technologies, although this is unsurprising as the fifty participants who took part were from project partners' organisations. Nonetheless, the responses grouped according to 'essential' or 'desirable' data presented clear indication of priorities that can be used as a guide for the development of A4BLUE systems. **User requirements that were assigned as 'essential'** are:

- Continuous data collection for performance and optimisation analysis.
- On-the-job work instructions to guide assembly or support processes.
- Re-configurability for introducing new automation (plug & produce capabilities).
- Direct connection to internal control systems.
- Constant recording of tool usage to improve maintenance.
- Performance monitoring for process improvement.
- Autonomous adaptation to new products and processes.
- Continuously linked systems for resource allocation.
- Automation / robot capabilities for utilising worker skills.

A larger number of additional 'desirable' user requirements were also derived from the survey data and will also be considered in development of A4BLUE systems.

4.2 A4BLUE ASSETS, APPROACH AND TARGETED USERS

A4BLUE is generating a number of outcomes that can be promoted, test-marketed during the project and exploited by the Consortium at the end of the project. These outcomes consist of both **tangible results** (software packages, platform) **and intangible results**, such as demonstrated training and learning methodologies and approaches to identify – for example – indicators for an objective evaluation of the workers psychophysical behaviours. Some of the results will have potential for joint exploitation, while for others the partners of the Consortium will maintain the option for pursuing individual exploitation, according to their IPR.

Furthermore, the partners have identified for the expected results, their main market sector of exploitation, **the aerospace,** as well as other sub-sectors of application of manufacturing, i.e. **shipbuilding, top class automotive and electric vehicles, wind power, capital goods, railway**.

The following table 3 shows the **tangible results** envisaged at M12, the target users and their advantages versus competitors solutions. It identifies the A4BLUE targeted end users for each tangible result and foresees why potential customers will choose to buy\adopt A4BLUE product\solution in place of those by competitors. Advantages may include unique features, price, new technologies or systems, better value to customers in terms of efficiency or cost/benefit ratios, greater compatibility with existing systems.

#	Exploitable result	Partner(s) involved	Target End user(s)	Advantage versus competitors solution
TR1	**A4BLUE Adaptive Framework**	ALL	Manufacturing Assembly based plants	**Main competitors**: none at the moment. **Advantages:** A4BLUE adaptive framework has to be considered as an open, secure, configurable, scalable and interoperable adaptation management and assistance systems that allows effortless integration of heterogeneous hardware and software components and is able to adjust the behavior of workplace parts according to changes. Among the main strengths it is possible to mention: FIWARE technologies which allow organizations capturing the opportunities that are emerging with the new wave of digitalization, brought by combining the Internet of Things with Context Information Management and Big Data services on the Cloud. This is a simple-easy-to-use and SINGLE interface where the required information for each task is shown to the operator in a friendly and easy way. As we explain, we believe from our experience that the complex way that the information is shown to the operator nowadays is one of the main reasons why workers feel unsatisfied. In addition other advantages are to: • Improve ergonomics and safety conditions of the operators. • Improve satisfaction of the operator. • Decrease the frequency of operators' sick leave. • Increase productivity. • Improvement of quality.
TR2	**Augmented Reality tool for assembly and auxiliary processes**	ILLOGIC, CESA	Manufacturing Assembly based plants Aeronautics	**Main competitors**: communities of open source programmers. **Advantages:** A4BLUE AR/VR framework relies on most used and most performing open source technologies today available. Communities of Programmers around the world assure and provide the needed technology evolutions. A4BLUE AR/VR framework can be evolved and customized to industries standards. Industrial Internet technologies enable VR and AR technologies to use real time data coming from specific equipment sensors in the plant through a smart data orchestrator and analyzer. For the *aeronautics sector* the main advantages are to: • Reduce operators training time. • Improve quality by reducing the number of mistakes made by the operator. • Reduce assembly cost and increase productivity. In addition CESA could use virtual or augmented reality for operators training.
TR3	**Virtual Reality based Training tool for assembly and auxiliary processes**			

#	Exploitable result	Partner(s) involved	Target End user(s)	Advantage versus competitors solution
TR4	**Collaborative Knowledge Platform for Manufacturing**	ENG, CESA	Large and small enterprises in the Industry domain Main sector: all industrial sectors Other sectors: all with ICT-based supporting aids	**Main competitors**: The main competitors for Collaborative Knowledge Platform are: Cisco Collaborative Knowledge, SAP Jam Collaboration Enterprise edition, Jive-n, IBM Connections 4.0. These solutions, which are already in the market as payware software, were realized to be adaptable in different markets. **Advantages:** Facilitating the transfer of knowledge, especially implicit and informal ones, from skilled workers (e.g. older workers) to young or less experienced workers. Collaborative Manufacturing Knowledge Platform can support workers in several industrial sectors in various aspects of their day life within the factory; for instance, it provides support to solve unforeseen problems within the workplace, to manage feedbacks and take-up of operational knowledge, to support training and educational activities using informal learning and social dynamics within the platform. The main foreseen advantages are to: • Ease platform customization to match with companies' needs. • Open Source framework. • Powerful data management system to enhance information integration by providing tool to streamline publishing, sharing, finding and using data. • Make it easier for the operator to share tips and knowledges between colleagues • Improve workers satisfaction. • Improve quality of the product, as the same mistakes will not be reproduced. • Reduce the scrap rate. • Increase productivity. CESA is planning to implement this tool in their use case scenario and use it also after the project end.
TR5	**Psychometric tool for valid and reliable assessment of worker satisfaction**	CRAN	Workforce, system designers, supervisors and managers, occupational health / ergonomists	**Main competitors**: none at the moment. **Advantages:** Identify ways to improve workers satisfaction. It allows solving workers problems sooner.

#	Exploitable result	Partner(s) involved	Target End user(s)	Advantage versus competitors solution
TR6	**Gesture based commanding solution**	TEK	-Technology/ Component provider -System integrator Technology/	**Main competitors**: LEAP MOTION, the pricing around 70€ and KINECT, the pricing around 140€. These solutions that are already in the market, are focus on the entertainment market. The Gesture based commanding solution´s main advantage versus LEAP and KINECT is the improved configurability as the system can learn new gestures and it is customized for industrial environment. **Advantages:** Improved configurability: the system can learn new gestures. The solution has functionalities to command a robot (or, potentially, any automation mechanisms) based on gestures performed by users (e.g. stop or start the robot). The modularity and flexibility of the solution offers the potentiality for enhancing the manufacturing process by enlarging the family of recognized gestures, by using different kinds of cameras or even by incorporating adaptation features beyond the project.
TR7	**Gesture and voice based commanding solution**	TEK	-Technology/ Component provider -System integrator	**Main competitors**: Besides LEAP and KINECT as main competitors for the gesture based commanding solutions, the additional competitors for the voice based commanding solutions are IBM Watson, Google assistant and SIRI. Regarding the pricing of IBM Watson, it is a licensing form that starts at 28,95€ per user per month or a professional license, with a multi-user tenant to collaborate, more storage and more data that starts at 77,20 € per user per month. **Advantages:** This solution combines the commanding of robots through the combination of voice and gestures based on semantic ontologies. Similarly to the previous result (gesture commanding), it offers interesting exploitation potentiality beyond the project to create a marketable product. The Gesture and voice based commanding solution has two main advantages comparing it to current solutions that are in the market: (I) the improved configurability as the system can learn new gestures and (ii) the voice and gesture systems integration, a functionality that doesn´t exist currently in the market customized for industrial environment.
TR8	**Adaptive safety monitoring system**	TEK	-Safety solution provider -Safety component provider	**Main competitors**: The main competitors are the “safety eye” with a pricing around 12.000€, the security laser of SICK and a laser sensor from HOCUYO, starting at more or less 3.000€ sale price. **Advantages:** The adaptive safety monitoring system monitors the distance between a robot (or an automation mechanism) and any objects (including persons) in a certain volume of space for safety

#	Exploitable result	Partner(s) involved	Target End user(s)	Advantage versus competitors solution
				purposes. It incorporates several sensors for monitoring the volume, which can be enhanced with new sensors for better precision in monitoring, besides adaptation features. Competitor's solution is based on just one sensor, while A4BLUE solution is based on several sensors. It allows: • More precision • More reliability • Allows tracking objects
TR9	**Collaborative assembly of latch valve demonstrator**	TEK	- Manufacturers companies (LE and SMEs)	**Main competitors**: none at the moment. **Advantages:** A demonstrator will be ready to showcase adaptive and collaborative assembly scenario to large and SME manufacturers. The demonstrator gathers A4BLUE technologies and solutions industrial potential (robotics, vision, sensors integration, production control and management….) in a tangible result which enables showing and transferring them to industry.
TR10	**Methods and tools for the evaluation of the socio economic assessment of adaptive automation**	RTWH	Factories	**Main competitors**: Based on recent state of the art analysis and literature reviews, there are currently no competitors and industrial solutions. The combination of the social and economic assessment of adaptive automation is partly addressed in research, not sufficient designed for application in production. **Advantages:** the methodology for the socio economic assessment of adaptive automation within A4BLUE is based on a modular approach. In this way each module can be addressed separately in terms of improvement on one hand and in case of changes in the workplace or production system a reassessment has to be performed only for the affected modules on the other hand. The modules are newly developed under the purpose of an interdisciplinary approach in order to combine worker satisfaction as well as usability aspects with economic assessment procedures.

Table 3 A4BLUE project tangible results

Table 4 reports the **intangible results** of the A4BLUE project and their targeted users.

#	Exploitable result	Partner(s) involved	Target End user(s)	Advantage versus competitors solution
IR1	**Networking with Stakeholders**	CTECH, ENG, TEK,ILL	Factories, all industrial sectors, aerospace All sectors with ICT-based supporting aids	people empowerment, soft and hard skills improvement
IR2	**Detailed knowledge of Adaptive Automation value chain applied to Manufacturing**	CTECH	Factories, all industrial sectors	
IR3	**Augmented and Virtual Reality know how**	ILL	Factories, all industrial sectors	
IR4	**Know-how in multimodal interaction**	TEK	All industrial sectors, service sectors (consumer)	
IR5	**Know-how in adaptive safety**	TEK	All industrial sectors, service sectors (consumer)	
IR6	**Know-how in connectivity and interoperability with legacy system and automation mechanism**	TEK, CESA, AIRBUS, KOMAT	All industrial sectors	

Table 4 Intangible results of A4BLUE and expected target users

A4BLUE proposes an innovative framework to develop agile, safe, flexible human-machines collaborative solutions. A4BLUE requires a European approach, in order to contribute to the ambitious goal of increasing the competitiveness of the European manufacturing companies and furthermore strength the position of automation companies, system integrators and solution providers that will deploy and maintain the proposed solutions. Cooperation and coordination at European level, will allow reaching a critical mass, built leadership and pursue common goals, creating a positive impact in Europe´s manufacturing sector.

Some scientific attempts try to develop **new models of interaction**. Researchers [13] have approached the need for a more context-sensitive task allocation that varies over time, depending on the human status and performance, or at the explicit request of the operator. In the literature [14]different **strategies for adaptive automation** can be found:

(1) Tasks can be allocated to either the system or the operator;

(2) Shift among modes or levels of automation based on a set of criteria or external events;

(3) Use real-time measures of operator activities to invoke the changes in automation.

Assembly systems have to be flexible to adapt quickly to an increasing number and variety of products and changing demand volume. To manage these dynamics, flexible, reconfigurable, and autonomous assembly systems were proposed in the last two decades, envisioning human-centred factories of the

future. Some representative projects are **AUTORECON, MANMADE**[16], **SATSFACTORY** and **FACTS4WORKERS**.

In the following table the main innovation of the A4BLUE solution with respect of these projects are mentioned.

Project name and brief description	A4BLUE solution advantages
AUTORECON project (http://cordis.europa.eu/result/rcn/164248_en.html) aimed at introducing auto reconfiguring autonomous production/handling units which can change task (from joining to handling and vice versa) and position (around the shop floor). AUTORECON proposed the enabling, development and introduction of a) autonomous, exchangeable and mobile production units, b) highly interactive robotic structures c) random (non-hierarchical agglomerates) production flow and all these, integrated under a common and open architecture.	Both projects pursue gaining more flexibility in assembly production lines. Both work on seamless integration of equipment. Nevertheless, A4BLUE envisions a human centered assembly workplace to balance flexibility and productivity, adapting automation to workers requirements and needs, compensating their limitations and increasing worker satisfaction.
MANMADE (http://www.man-made.eu/) Manufacturing through ergonomic and safe anthropocentric adaptive workplaces for context aware factories in Europe.	Both projects aim at getting more sustainable and ergonomic workplaces. However, A4BLUE has an important focus on multimodal interaction mechanisms among workers and automation mechanisms to optimize human variability.
SATISFACTORY (http://www.satisfactory-project.eu/) is a H2020 project that envisions a collaborative and augmented-enabled ecosystem for increasing satisfaction and working experience in smart factory environments. The architecture of such ecosystem includes a Smart Sensor Network; components to support decision, increase safety satisfaction and training; and interactive visualization through AR (augmented reality).	A4BLUE will offer an open architecture that will facilitate an evolvable production system. Major innovation of A4BLUE Adaptive Framework is the inclusion of the automation adaptivity perspective within the framework. While other acknowledged platforms, ecosystems or reference architectures deal with sensor networks, training through AR, decision support and interactive visualization, A4BLUE includes also the capability of the system to adapt new and existing automation equipment to the workers requirements, either physical or related to their skills, expertise, or even cultural background.
FACTS4WORKERS (http://facts4workers.eu/) envisions the integration of available IT enablers into a seamless and flexible Smart Factory infrastructure based on worker-centric and data-driven technology building blocks.	FACTS4WORKERS shares with A4BLUE the approach on multimodal interaction mechanisms among workers and equipment. A4BLUE offers, in addition, adaptation of that equipment to worker´s needs and profile.

Table 5 A4BLUE with respect to other EU projects

This **aeronautic sector** is characterized by a **few large companies** that in turn work with a large number of suppliers of specialized components, which are often SMEs. The strategy in this sector is based on the demonstration scenarios of AIRBUS and CESA. In the short term, the aim is to attract suppliers

relevant to Airbus & CESA and in the medium term reach other aerospace companies and their value chains.

The initial market approach was set according to the type of targeted end users envisaged: this will influence the A4BLUE product expectations and the future exploitation strategy. It should be reminded that each exploitable result of A4BLUE could have different business approaches depending on the value chain organization, the economic benefits brought by A4BLUE in each targeted applications and the best stakeholders to bring the solution to market. These activities will be carried on along the next 2 years project and reported in the next deliverable.

The proposed solution architecture aligns with the Internet of Services (IoS) concept and could support different business models ranging from **on premise deployment of the solution** to **Software as a Service (SaaS) approach**.

This could allow manufacturing companies to adopt A4BLUE by providing them ad-hoc solutions, which allows for evolutionary scalability and maintenance flexibility aligned with their needs over time.

4.3 TARGET MARKET SEGMENTS

4.3.1 Primary target market: aeronautics

Aeronautics is a strategic industry in the EU. 2014 turnover level represents 140.5 billion euro employing 534,621 workers, 35% in production activities. In 2013 the Spanish aerospace industry ranked fifth in Europe with a turnover of 13,803M€. Round figures for total export (intra and out of Europe) show an amount of 109 billion euro out of which 68 billion euro represent exports outside of Europe and 41 billion euro as intra-Europe. This sector is characterized by a few large companies that in turn work with a large number of suppliers of specialized components, which are often SMEs. The strategy in this sector is based on the demonstration scenarios of AIRBUS and CESA. In the short term, the aim is to attract suppliers relevant to Airbus & CESA and in the medium term reach other aerospace companies and their value chains.

The aeronautic industry and particularly the manufacturing of aircraft structural parts have the characteristics of complex process, large variety, small batch and frequent change of production plans. In order to shorten lead time and reduce cost, high-efficiency communication and collaboration among manufacturing departments are required [17].

A4BLUE aims to bring an innovative adaptive approach to address the challenge of producing highly complex, small batch, variable demand products under strict time and cost constrains in the aeronautics sector, through the introduction of adaptive and sustainable automation systems but always focusing on increasing workers satisfaction by lowering efforts needed for setting up and executing operations and compensating workers 'limitations.

The civil aviation industry is dominated by Airbus and Boeing. Both companies have large order books that should keep their production lines busy for almost a decade. The long term cycle, the continued attractiveness of existing models and the upcoming new aircrafts should support the already hefty backlogs.

The Spanish company **CESA** is the leader in the European market in the development and assembly of fluid-mechanical equipment for aeronautics industry. The clients include EADS/CASA, **AIRBUS Military, AIRBUS**, Eurocopter, Messier-Dowty, Sikorsky Aircraft Corporation, IAI/Gulfstream and Eurofighter.

The 2017 Global aerospace and defense outlook reviews the industry's performance in 2016 and expectations for 2017 [18]. Following multiple years of positive but a subdued rate of growth, the report forecasts the sector revenues will likely grow by about 2.0% in 2017. Stable global gross domestic product (GDP) growth, relatively lower commodity prices including crude oil, and strong

passenger travel demand, especially in the Middle East and Asia Pacific regions, will likely drive the commercial aerospace sub-sector growth.

Travel demand (revenue passenger kilometers) *has been increasing at a compounded annual growth rate (CAGR) of 4.7% over the last ten years*, with passenger enplanements rising from slightly over 2.0 billion to more than 3.5 billion annually during this period [19]. Increase in travel demand has been primarily driven by global demographics and wealth creation in Asia and the Middle East, resulting in a significant order increase for new aircrafts. *Passenger and freight traffic* are likely to grow at an average annual growth rate *of 4.8% and 4.2%,* respectively, over the next 20 years, contributing to higher aircraft production [20]. As illustrated in Figure 12, passenger travel demand increased more than five times from 1981 to 2016, while passenger load factor (utilization of aircraft) has risen 25.6% (nominally growing from 63.7% to 80.0%) during the same period.

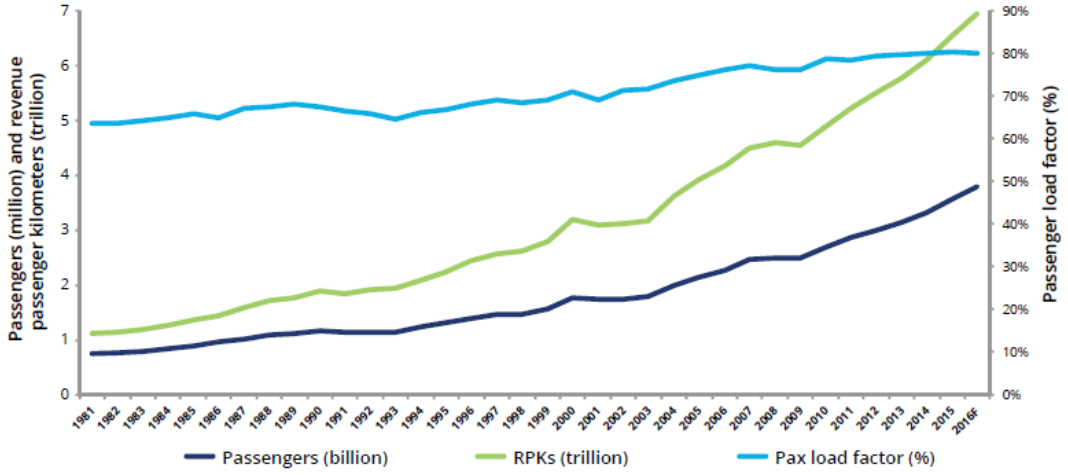


Figure 12 Global airline traffic 1981-2016

Despite an expected increase of 96 additional large commercial aircraft being produced in 2017, continued pricing pressure and product mix changes by airline operators will likely result in only a marginal increase of 0.3% in commercial aerospace sub-sector revenues. Major aircraft manufacturers, **Airbus and Boeing**, have indicated production rate increases will occur in 2017 and 2018. Airbus' A320neo is likely to ramp up production in 2017, whereas, Boeing estimates that the production rate of its 737 will rise from 42 per month currently to 47 per month in 2017 and 52 per month in 2018 [21].

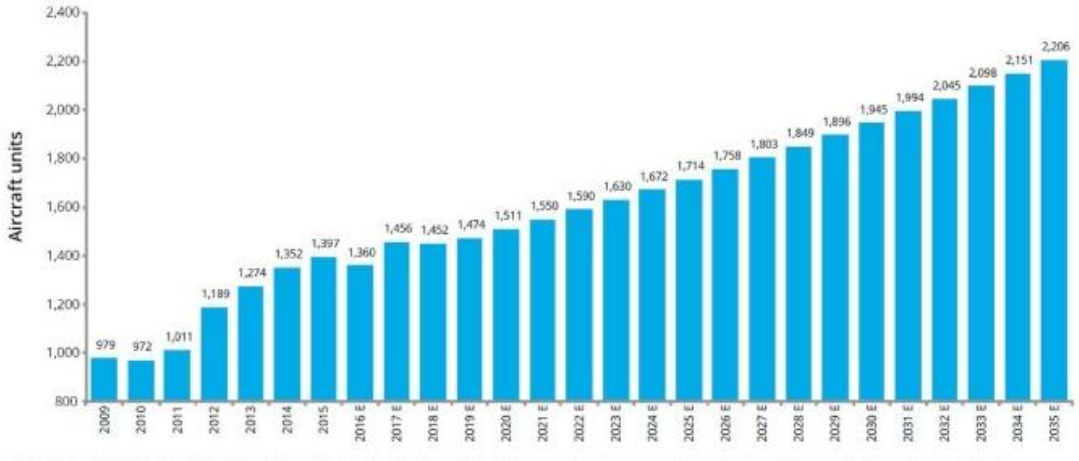


Figure 13 Aircraft deliveries forecast till 2035. Source Deloitte analysis.

With such growth expected, there are two significant trends and challenges to consider — the attractiveness of this market and the resulting entrance of new global competitors to the existing duopoly, and the impact on the supply chain.

The aircraft measured in RPK (Revenue passenger kilometers) will double in the next 15 years with and annual growth varying between 5,5%-7,1% in the Asia-Pacific and in the Middle East regions. It is forecasted that the market for airplanes features a value of $4.4 trillion during 2013-33, i.e. more than 28,000 Airplanes. A 4,7% annual growth rate in emerging regions like China, India, Middle East and Eastern Europe is predicted.

As the overall commercial aerospace market grows, new aircraft production programs are emerging from other regions, particularly in *China and Russia*. Although China has been attempting to produce and deliver a domestic manufactured commercial aircraft for nearly four decades, it has not seen great success. With the C919, China seems to be more focused on the program and is also working with foreign suppliers that have experience in various aircraft programs [22]. However, these new entrants will face multiple challenges, including procurement of orders from established carriers, risk of budget and schedule over-runs in product development, as well as delays in establishing a track record of reliable, safe, and trouble-free operation, which could be a lengthy process.

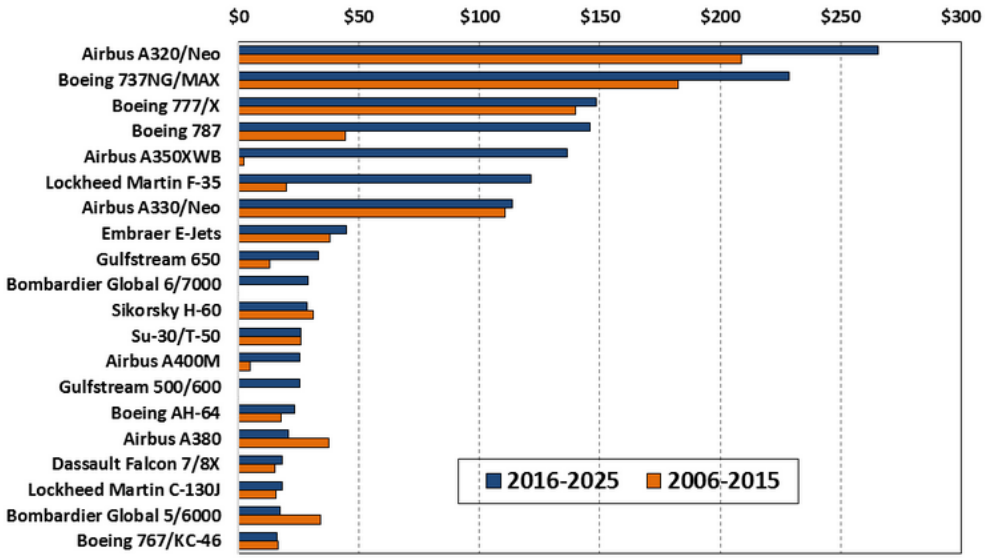


Figure 14 Top 20 aviation programs – Volume Matters: cumulative deliveries value in 2016 billion $

The global supply chain faces a challenge to ensure that increasing requirements for capacity, throughput, quality, on time delivery and pricing can be met. The aerospace supply chain is expected to continue its transformation to reduce costs, respond quicker and to invest more in product innovation, which may result in further industry consolidation as some of the smaller companies may not be able to meet the increased financial, program management, skills, risk-taking and investment requirements. Much like any other industry, Aerospace will have to face increasing competition and adjust to emerging and developing markets. Demand for new and innovative technology will also be strong from countries like America, the UK and France. Joint ventures between companies will become more apparent, as countries look to be dealt with on an individual basis, and information swapping between Aerospace businesses may lead to desired significant technological breakthroughs.

4.3.2 Secondary target market: Electric vehicles

The global stock of electric vehicles (EVs) reached 1 million during 2015 and passed the 2 million mark in 2016. This rapid rise has been led by China, the US, Japan and several European countries [23]. The uptake of EVs is the result of several factors, including strong technological progress, cost reductions

(especially batteries), and policy support, including purchase incentives, driving and parking access advantages, and increased public charging infrastructure availability.

Battery electric vehicles (BEVs) dominated sales over plug-in hybrid electric vehicles in most countries until 2014, but plug-in hybrid electric vehicle (PHEV) sales have grown rapidly in the past two years and as of early 2016 were nearly equal to BEV sales worldwide.

PHEVs have a considerable range advantage but sacrifice all-electric driving to achieve this.

Despite on-going battery performance improvements and cost reductions, EVs still face potentially important obstacles.

New models to be introduced in 2017 and 2018 will be able to drive up to 300 kilometers (km) per recharge, but battery packs up to 60 kilowatt-hour (kWh), even if battery costs drop from their current levels of around USD 350/ kWh to USD 150 kWh in the future, would cost USD 9 000, much more than the drive systems of today's internal combustion engine vehicles. Fuel savings will help pay this back, especially for high-mileage drivers.

Battery-electric vehicles provide zero-vehicle-emissions driving (for both carbon dioxide (CO2) and pollutant emissions), but the "upstream" CO2 can be substantial, for example in countries with dominant coal power generation. Electric grids must be considerably decarbonised (to 600 grams (g)/ kWh or less) for EVs to have a CO2 advantage relative to similar sized hybrid internal combustion engine (ICE) vehicles.

Carbon intensities will need to continuously improve in the future, since hybrids and other ICE vehicles will also become more efficient. EVs also produce no direct air pollution and reduce noise pollution in cities.

For the most benefit, EV deployment requires four concurrent strategies:

(i) Electrification of vehicles;

(ii) Provision of sufficient charging equipment;

(iii) decarbonisation of the electricity generation;

(iv) Integration of electric vehicles into the grid.

EV deployment growth would allow a higher share of variable renewable energy in the power system, via five areas of interaction:

(i) Actively using the mobile battery storage system in the vehicle;

(ii) Use of second-hand batteries in a "second life" role as stationary battery storage systems;

(iii) Widespread deployment of charging technologies and infrastructure;

(iv) evolution in the charging behaviour of EV owners, for example, in which they become comfortable with variable charging rates and times;

(v) provision of other ancillary services from EVs to the grid, such as frequency regulation, shaving peak demand, power support to enhance operation, and reserve capacity to secure the grid by stored energy in its batteries.

Electric vehicles create a paradigm shift for both the transport and power sectors, and could support variable renewable power growth through different charging schemes such as time-variable "smart charging" and vehicle to grid electricity supply. Such systems can help support a global doubling of the share of renewable energy by 2030 compared to 2015.

The eventual deployment of charging schemes such as smart charging and V2G can support the growth of variable renewable energy and can interplay with information communication technology (ICT)

systems to maximise the technical features and minimise the operation costs using demand-side management tools.

REmap – a global roadmap from the International Renewable Energy Agency (IRENA) to double renewables in the energy mix – estimates that a 160 million EVs by 2030 would provide sufficient battery capacity in major markets to support VRE at a large scale. Achieving this stock level, however, will be challenging and will require annual sales growth rates on the order of 30-40% between now and then. To achieve this will probably require that EV markets achieve a "tipping point" between 2020 and 2025, when they start to rapidly increase market share relative to ICE vehicles.

To achieve a tipping point in sales, EVs will likely need to achieve near parity on a first cost basis with ICE vehicles, and provide sufficient amenities (such as driving range and recharging convenience), such that consumers do not consider them inferior to or comparable to ICEs. EVs are already perceived to provide an excellent driving experience, and new models being introduced during 2017 and 2018 will have much greater driving range than most of today's models.

But strong policies to *a)* reduce the first cost of EVs, *b)* provide driving/ parking advantages, and *c)* ensure sufficient recharging infrastructure, will likely all be needed for at least five to ten more years to have a chance for rapid sales growth and achieving target stock levels by 2030. Assuming all these new electric vehicles were to consume 100% renewable electricity, around 450 terawatt-hours (TWh) per year of additional renewable electricity would be required by 2030. This is equivalent to 1.5% of today's total global electricity generation.

Benefits of EVs include zero tailpipe emissions and therefore less local air pollution and, depending on the power generation, lower CO2 emissions. EVs can also reduce noise pollution in cities. Governments should also consider promoting electric two-wheelers and electric buses as a way of reducing pollution and noise in populated regions where point-to-point charging is possible.

Regarding Electric Vehicles, the **global electric high performance vehicle market is expected to grow at a CAGR of 72.67% during 2014-2019 [24].** In 2014, 75,331 new electrically chargeable vehicle 1 ECVs were registered in the EU, a 36.6% rise. Looking at the EU's major markets: the UK saw the largest increase over the year (+300.8%), followed by Germany (+70.2%) and France (+29.8%). The forecast trend for the **European Electric Vehicle Market in 2017 expects a 2.2 million unit sales**.

4.3.3 Secondary target market: Top class automotive

Automotive Sector 2,3 million jobs in direct manufacturing (7.6% of EU employment in manufacturing) demonstrate the relevance of the sector for the European Economy. The automotive industry is responsible for a fifth of world automotive production (90.6 million motor vehicles were produced globally in 2014). Automobile manufacturers operate over 292 vehicle assembly and production plants across 26 countries in Europe. Europe's automobile industry produces the cleanest, safest, quietest and most efficient vehicles in the world. However, staying competitive in the global race is a challenge that European industry needs to work towards.

With significant upcoming changes in powertrain technologies and their effects on increasing investments, the profits of today's OEMs will decrease. **Digital ecosystem will be the main source for revenue and not the car itself [26]:** the digital ecosystem can counter strike these developments and generate higher revenues in the automotive value chain than the hardware of the car itself reflecting both data streams, the one generated within the car (upstream) and the one customers bring into the car (downstream). Looking at the development of new business models outside of the automotive industry, this development seems very likely to become true. When the main source of revenue in automotive industry shifts away from the car itself, current value drivers have to be reevaluated or respectively new value drivers will have to be identified and integrated into a new business strategy. Data is the foundation of digitalization and therefore the automotive industry must see it as a core element. A key challenge will be to make the business model profitable. In order to do so, new

capabilities and competencies must be developed. *When looking at executives by job group, this year's survey results show that CEOs agree the most about the digital ecosystem being the main revenue source for the automotive industry*. This underlines the importance of the results, because CEOs are committed more than other job groups to foreseeing upcoming trends and anticipating their influences on business development. **85%** *of executives absolutely or partly agree that the digital ecosystem will generate higher revenues than the hardware of the car*.

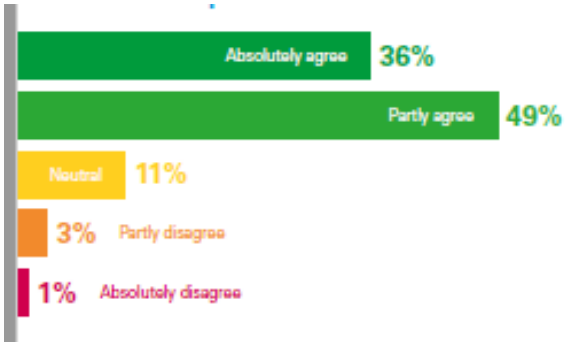


Figure 15 Executive viewpoint: CEOs agree the most. Source: KPMG's Global Automotive Executive Survey 2017.

OEMs understand that they have to decide on whether they want to become "Metalsmiths" or "Grid Masters". In 2016 for the first time executives saw the production and sale of an automobile and the operation of a digital platform to manage direct customer relationships offering vehicle dependent and independent services over the whole customer lifecycle (Grid Master) as the favored business model for OEMs. Compared to last year's results, OEMs do realize that being stuck in the middle is not a real option. **35% of executives** believe that **OEMs will become the "Grid Master"** – making it the most favored business model.

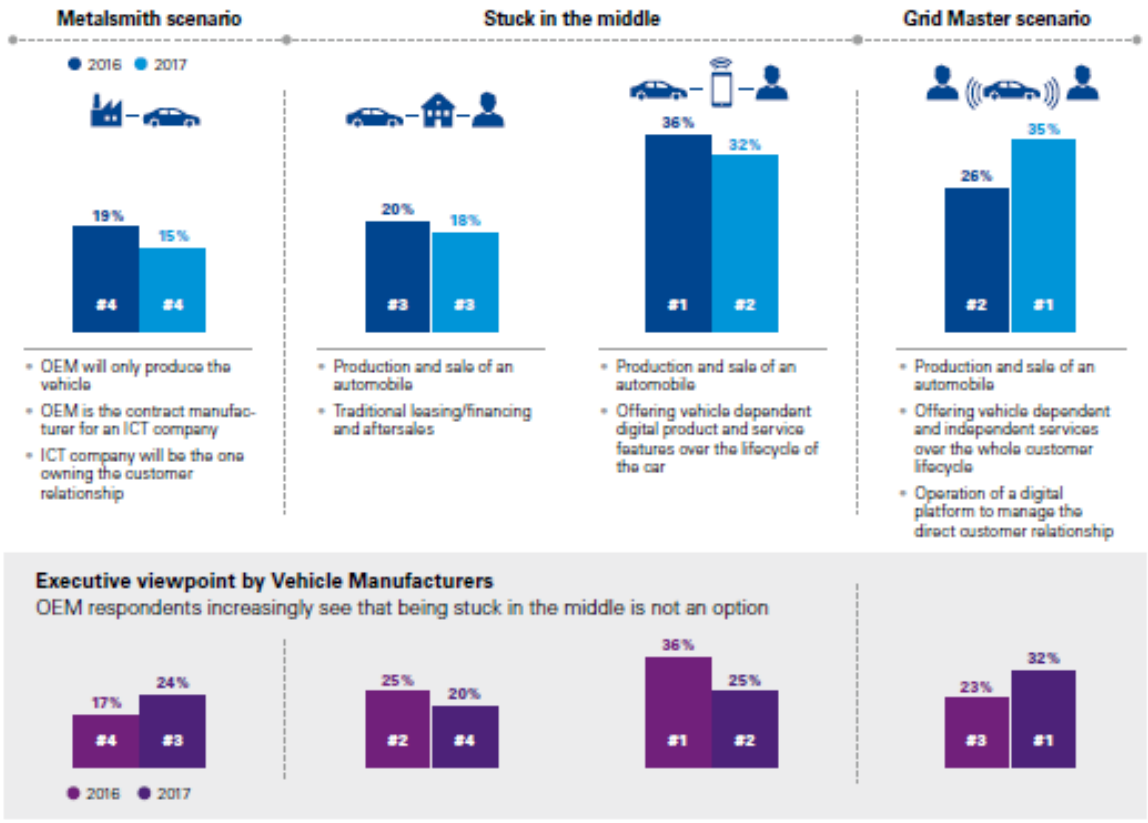


Figure 16 Three automotive future scenarios description. Source: KPMG's Global Automotive Executive Survey 2017.

The *global luxury car market* has seen been relatively untouched by the financial crisis and has been posting growth driven by the emerging markets [26]. The three German players **BMW, Audi and Mercedes-Benz** account for approximately 80% share of the global luxury car market. BMW is the global leader in the luxury car segment, followed by Mercedes-Benz and Audi. In the United States luxury car market, over the past few years, it is the crossovers and SUVs, which have been experiencing growth in sales. In 2016, the two leading players in the market, Mercedes-Benz and Lexus did not see any of its non-SUV models experience growth in sales. The luxury car market in the US is now diverging into two clear categories, the budget cars and the ultra-luxury cars.

Demand for luxury cars in Europe had been at a low for nearly two decades and started recovering gradually from 2014. Even though challenging economic conditions still prevail in many European markets, players such as BMW have been able to maintain volumes of their higher end models. In Europe, there is greater demand for high-end models as compared to the emerging markets such as China where the entry-level luxury markets are seeing greater growth. New players in the market such as Hyundai have big plans for Europe even though traditionally the foreign players have not been able to match the big 3 German brands which account for approximately 4 out of 5 luxury cars in the market.

In 2017, the luxury car segment in China is seeing strong growth. Despite the government's austerity drive, sales of super-luxury and supercar sales have not slowed down in China. Mercedes-Benz witnessed its best ever month in terms of sales in China in March 2017.

India is one of the largest passenger vehicle markets in the world and vehicle manufacturers both in the passenger and luxury segment see a huge potential for sales growth in the country. While the luxury car penetration level in the country is low but leading luxury car manufacturers are betting on the market's potential. Luxury car penetration in India currently stands at 1.1%. Launch of multiple strategically priced models at various price points coupled with smart financing schemes and a robust dealer network is boosting the sales of luxury cars in India.

In the GCC region, the United Arab Emirates is the second-largest automotive market after Saudi Arabia. U.A.E. is heavily dependent upon imports and almost the entire supply of car as well as light vehicles is imported. The low oil prices and global macroeconomic factors are affecting the luxury goods market in the Middle East. While over the last 10 years the personal luxury goods market witnessed an annual growth of 8-10%, it is projected to drop to approximately 4-5% over the next few years. Even amidst the economic slowdown globally, the sales of luxury cars per capita are still the highest in the Middle East.

Super luxury cars are almost an obligatory status symbol for ultra-rich individuals, and according to JATO statistics [27], a record 28,500 of them were sold in 2016 (figure 13). That's a 15.9% increase on 2015 with demand fueled by China in particular. *Bentley and Ferrari* were the heavyweights in the super luxury car segment in 2016, commanding a market share of 37% and 24% respectively. Lamborghini came third with 11% while Rolls-Royce and Aston Martin had 10%. The top three selling super luxury car models last year were all *Bentleys*: the Continental came first, followed by the Flying Spur and the Bentayga. Demand was highest in the United States which accounted for 30% of the global sales volume, equating to 8,377 vehicles. The UK came second with 4,600 units sold, while China followed closely behind with sales surpassing 4,400.

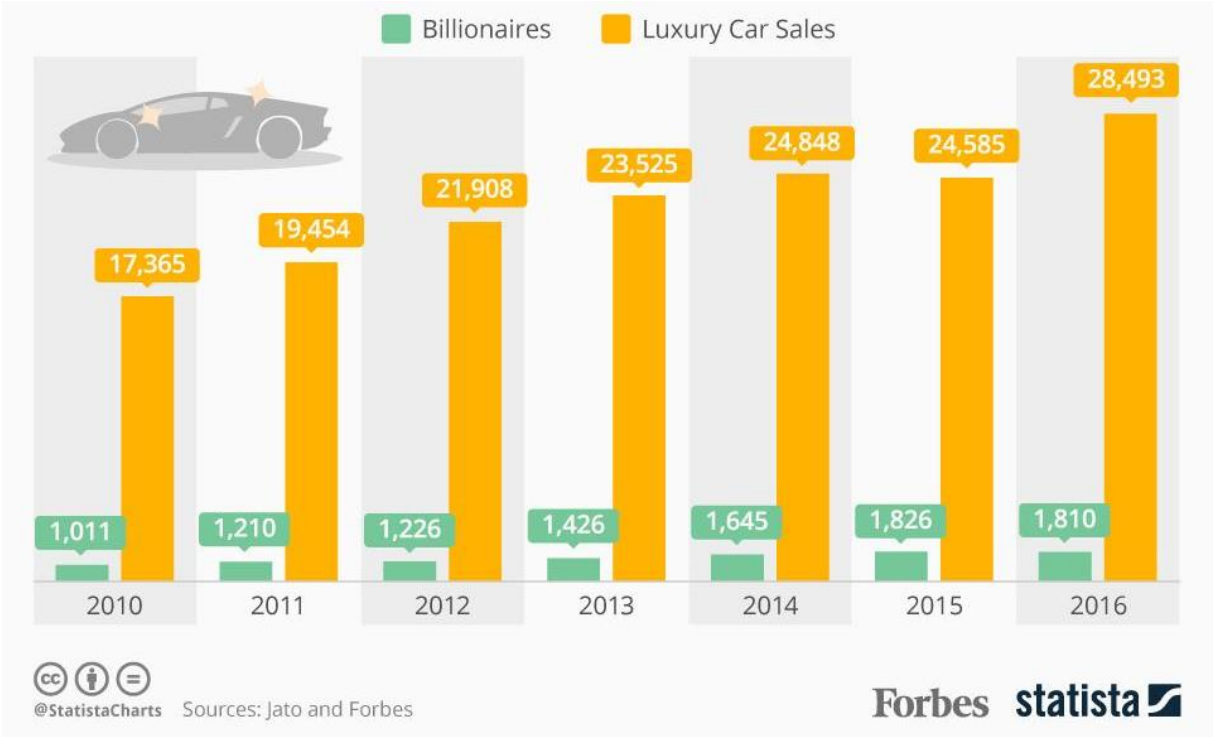


Figure 17 Super Luxury Car sales and global billionaire population by year

4.3.4 Secondary target market: Capital goods

Since mid-2014 when oil prices started to plummet, we have downgraded many capital goods companies. This negative ratings momentum is likely to persist because of the low-growth, low commodity price environment. In 2016, there were more downgrades in the capital goods sector than in any given year since the Financial Crisis. However, **ratings in the capital sector should remain somewhat steady in 2017,** given that 71% of all rated companies have stable outlooks [28]. Nevertheless, a clear negative bias in outlooks persists. Notable rating actions during 2016 include the downgrades of General Electric (AA-/Stable/A-1+), Pentair (BBB-/Stable/A-3), Dover Corp. (A-/Negative/A-2), Joy Global (BB+/Watch Pos/--) and Toshiba (CCC+/Watch Neg/C). Furthermore, we revised our outlook on Caterpillar (A/Negative/A-1) to negative from stable. Other global industry players such as Honeywell (A/Stable/A-1), Hitachi (A-/Stable/A-2), Komatsu (A/Stable/--), Siemens (A+/Stable/A-1+), ABB (A/Stable/A-1), Thyssenkrupp (BB/Stable/B), and Schneider Electric (A-/Stable/A-2) held their ratings as well as outlooks.

For the capital goods sector globally, we expect a modest recovery in revenues and operating profit in 2017, as well as a slight improvement of credit metrics from 2016 levels. *We expect the partial recovery of commodity prices, as well as our base case of a moderately supportive macroeconomic environment, to favorably influence revenues.* This positive effect is most pronounced in the U.S. compared with EMEA and APAC (Figure 18).

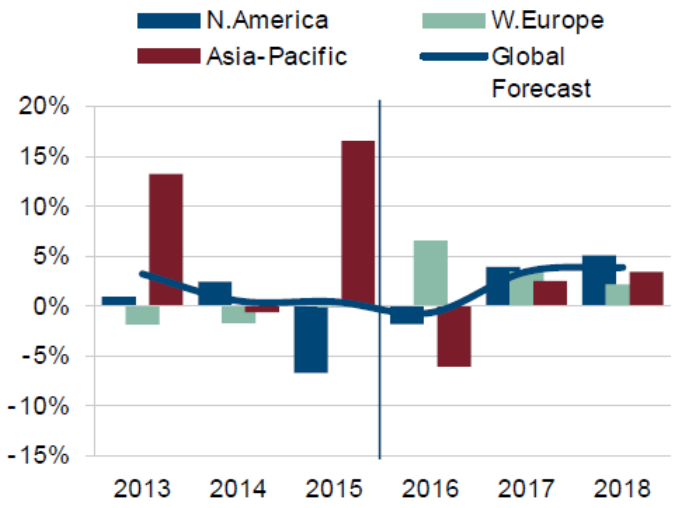


Figure 18 Global Capital Goods: revenue growth (local currency)

Global economic growth remained soft in 2016 but S&P Global Ratings expects it to pick up in 2017, *driven by emerging markets and developing economies*. Key expectations for 2017 include inflation returning to the Eurozone, a stronger U.S. dollar and a persistent slowdown of growth in China. However, 2017 is surrounded by macroeconomic uncertainty and event risk around the new U.S. administration's economic and fiscal policies, elections in major Eurozone countries, and the negotiated exit of the U.K. from the EU. These macroeconomic events could directly impact the capital goods sector, as earnings are derived from end customers' capital expenditure, which is in turn linked to the broader economic climate.

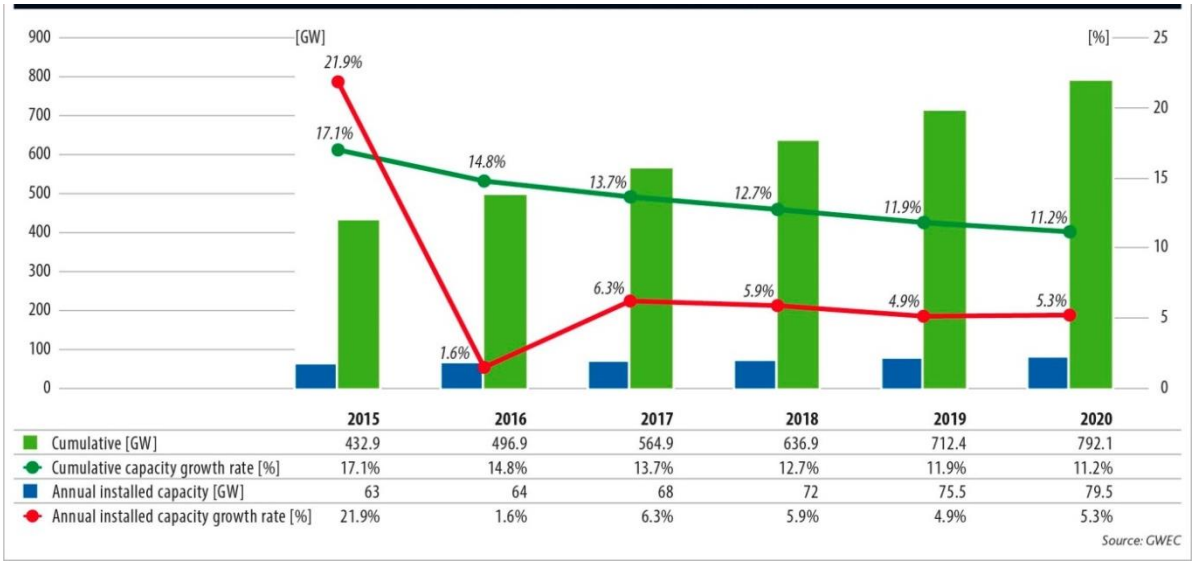
Digitalization of manufacturing is a crucial long-term opportunity: "Industry 4.0" or the digitalization of products and the manufacturing process presents one of the greatest structural opportunities and challenges for capital goods companies in 2017 and beyond. S&P Global Ratings sees substantial scope for manufacturers to enhance productivity through digitalized processes, especially for early adopters. Over the next few years, we expect Industry 4.0-related spending on R&D and new assets to squeeze some budgets and we see scope for some consolidation and M&A as companies expand their digital capabilities beyond their core competencies.

From a macro perspective, *European capital goods companies* still face a more challenging low-growth environment: S&P Global Ratings forecasts the economic recovery will continue gradually and **GDP** will grow at **1.5% in 2017** (1.8% in 2016). We expect 2017 to mark the return of inflation to Europe as higher oil prices and depreciation of euro and the pound are pushing up prices. However, the ECB's monetary policy is likely to remain accommodative throughout 2017. For the capital goods sector, the weakness of both the pound and euro allows for cheap exports but this is mitigated by the softness in global trade. It is our expectation that, despite slower economic growth in Europe, the current macroeconomic climate will support a recovery of the capital goods sector, accompanied by low default rates, as issuers benefit from low interest rates and abundant liquidity in the market.

4.3.5 Secondary target market: Wind industry

After setting a new record in 2015 passing 60GW for the first time, the wind industry had a year of consolidation in 2016 [29]. China 'only' installed 23GW, and cyclical or policy related slowdowns in key markets such as Brazil, Mexico, South Africa and Canada meant that the industry was not able to set another record in 2016, but still installed 54.6GW during the course of the year. A number of countries set records in 2016, most notably India, with its all-time high total of 3.6GW. **At the end of 2016, total global installed capacity was 486,790MW**. Global Wind Market Report expects the annual market to return to growth in 2017: policy-induced rush to install will drive market growth in China, although it

is unlikely to reach the 30GW record set in 2015; stable markets in Europe and North America; continued growth in India; a general pickup in Africa and Latin America; and some new markets putting up numbers for the first time (Figure 19Figure 22).



	2015	2016	2017	2018	2019	2020
Cumulative [GW]	432.9	496.9	564.9	636.9	712.4	792.1
Cumulative capacity growth rate [%]	17.1%	14.8%	13.7%	12.7%	11.9%	11.2%
Annual installed capacity [GW]	63	64	68	72	75.5	79.5
Annual installed capacity growth rate [%]	21.9%	1.6%	6.3%	5.9%	4.9%	5.3%

Figure 19 Market Forecast for 2016-2020

Regarding onshore and offshore wind energy growth, the **onshore growth** has proliferated in *emerging markets*, whereas *mature markets* are focusing the growth in **the offshore sector** and the repowering of existing assets to meet renewable energy targets.

While the **offshore industry** was expecting prices to gradually decrease towards the target of €100/MWh by 2020 that it had set itself, everyone was surprised at how quickly it has actually happened. Starting in July with the Dutch tender for the 700MW Borssele 1&2 projects [30] at €72.7/MWh (USD 78.5), the action then moved to Denmark with their nearshore tender which came in in September at €64/MWh (USD 69.1), followed in November by the Kriegers Flak project [31] at €49.9/MWh (USD 53.9), and returning to the Netherlands in December with the Borssele 3&4 project [32] for another 700MW at €54.5/MWh (USD 58.9). A spectacular drop in price, by any measure, which has certainly defined a range for 'the new normal' in mature northern European offshore wind markets at well below €100/MWh. Now, it should be noted that these projects are exclusive of transmission costs, which would add another €6-12/MWh, and that they are not in either very deep water or very far offshore. **Regardless, it seems that the industry has exceeded its 2020 targets by a significant margin, and four years ahead of time.** There is a remarkable situation where all of a sudden offshore is competitive with onshore wind, and the repercussions have been felt across the world, setting the stage for a round of large investments in offshore not only in Europe, but also in Asia and North America.

The **overall EU wind energy market** was up very slightly in 2016: Germany passed the 50,000MW in cumulative installations but also France, Turkey and The Netherlands had a strong 2016. Offshore installation are expected to be up again in the next years, since Europe is expected to proceed in line with its 2020 targets, installing about +73GW of new wind power.

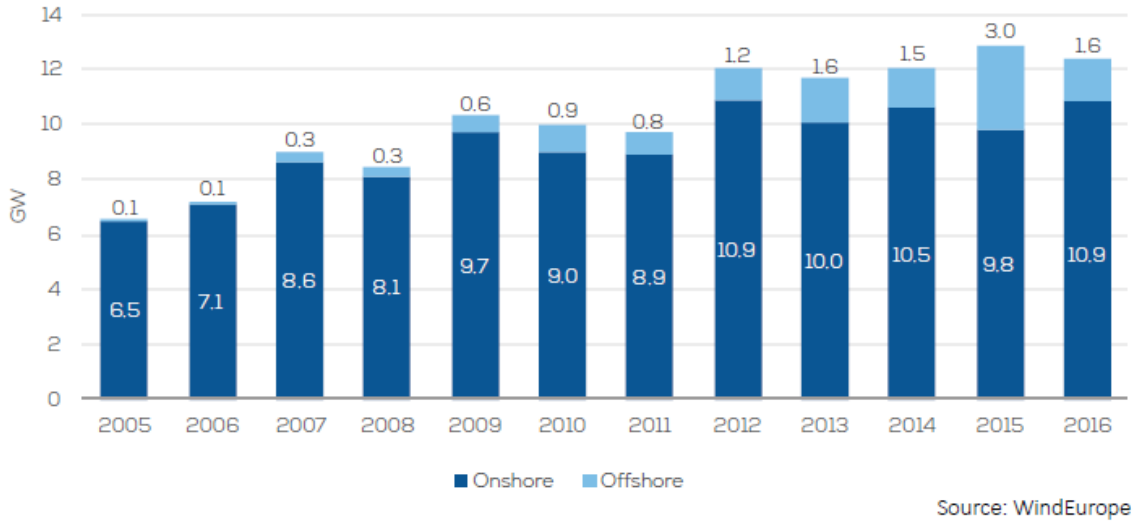


Figure 20 Annual onshore and offshore wind installations in Europe

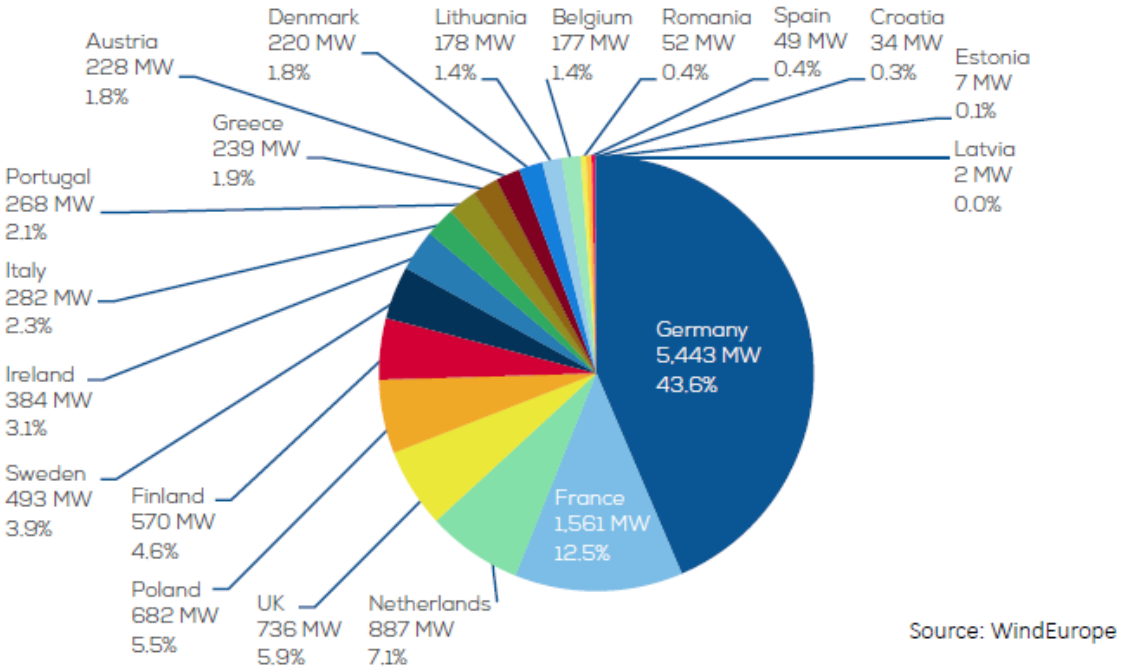


Figure 21 EU market shares for new wind energy capacity installed in 2016

In the first trimester of 2017 the top global wind turbine manufacturers were [33]:

a) Vestas (Denmark - https://www.vestas.com/)

With headquarters in Aarhus, Denmark, Vestas is involved in design, manufacture, installation, and servicing of wind turbines across the globe. Employing over 21,800 globally, the company has manufacturing facilities in several countries that include Denmark, Germany, India, Italy, Romania, the UK, Australia, China, and the US, among others. It has installed 82GW of wind turbines in 76 countries.

In 2016, the company received a total of 10,494MW wind turbine orders from 33 countries. The Danish turbine maker opened a new hub and nacelle production unit in Aquiraz, Brazil to cater to the Latin American market. Recently, MHI Vestas Offshore Wind, a 50/50 joint venture of Mitsubishi Heavy Industries (MHI) and Vestas Wind Systems, rolled out an upgraded version of the 8MW wind turbine platform that can reach 9 MW at specific site conditions.

b) **Enercon (Germany - http://www.enercon.de)**

Founded in 1984, the Germany-based Enercon manufactures wind turbines and energy converters. It manufactures components for its wind energy converters included annular generators, inverters, rotor blades, cast components, towers and machine houses. It operates a research company I4E to support the development of new products. As a turnkey supplier for wind energy projects, Enercon operates 37 sales offices worldwide. It has installed over 43.5 GW of wind energy capacity globally, with 20GW in Germany alone.

c) **United Power (China - www.unitedpower.com/)**

Guodian United Power Technology Company (United Power) is a state-owned Chinese company that provides a range of solutions for wind turbine generator systems. Headquartered in Beijing, it is wholly-owned by China Guodian Corporation Group, which is one of the five largest state-owned power generation groups in China. Its product portfolio includes wind turbine series with rated capacity of 1.5MW for normal, high altitude, tideland & coastal, and low temperature conditions. It claims to have independently developed double-fed offshore wind turbines with rated capacity of 3MW. According to its website, the company owns five subsidiaries, three holding companies and six manufacturing and R&D bases in six cities across China.

d) **Siemens Wind Power (Germany\Denmark - https://www.siemens.com/global/en/home/markets/wind.html)**

Siemens Wind Power is a separately managed wind business of the German conglomerate Siemens, with over 35GW of installed wind power capacity. To date, the firm has installed nearly 2,100 offshore wind turbines, with a total capacity of more than 7GW. Its geared wind turbines have rotor diameters of up to 130 meters and a nominal power of up to 4 MW. The company claims that its direct drive turbines can reach nominal ratings of up to 8 MW and excel with a rotor diameter of 154 meters. In December 2016, it opened new rotor blade factory for offshore wind turbines in Hull, UK. It is also constructing €200m new wind turbine manufacturing facility in Cuxhaven, Germany.

e) Gamesa (Spain - *www.gamesacorp.com)*

Gamesa is a Spanish firm involved in the manufacture of wind turbines and the construction of wind farms. The company also offers wind turbine's operation and maintenance services. It has a global installed capacity of over 35.8GW, with a presence in 55 countries. Gamesa's facilities in Spain and China serve as its global production and supply hubs. It also maintains its local production capacity in India and Brazil. In February 2017, it opened a new blade facility in India, where it has installed over 3,500 MW of capacity. Recently, the European Commission approved the merger of Siemens Wind Power and Gamesa.

f) GE Renewable Energy (USA - *https://www.gerenewableenergy.com/*)

GE Renewable Energy is one of the major wind turbine manufacturers, supplying 1.7 MW to 3.8 MW rated turbines for onshore projects and 6MW for offshore. Supplying over 30,000 turbines across the globe, the company also provides support services for wind farms. Last year, it acquired the Danish maker of rotor blades LM Wind Power, which has over 190 patents and produced 185,000 blades since it opened for business in 1978.

4.3.6 Secondary target market: Shipbuilding industry

Europe has a leading position in the shipbuilding global market. **Shipbuilding sector in turn facilitates the EU's blue economy, which supports 5.4 million European jobs and represents a gross added value of just under €500 billion per year** covering a wide range of shipping operations, ports facilities, a host of coastal industries, off-shore operations, inland and seagoing passenger and cargo trades and European security.

According to EU, the shipbuilding industry deals with the **production of larger vessels intended for the merchant fleet (cargo or passenger transport), the off-shore energy industry or military purposes.** It also includes products and services supplied for the building, conversion, and maintenance of these ships.

Shipbuilding industry is heterogeneous in many respects, such as:

- Diversified markets (shipbuilding, ship repair, naval shipbuilding, boatbuilding, offshore oil & gas, offshore wind, underwater etc.),
- Generalists or firms focussed on one market; different in size (big, medium sized and many small companies), global market leaders versus regional workbenches, and
- A broad and varied customer base (shipyards, shipping companies, governments, private owners, offshore majors, research institutions).

Shipbuilding is an important industry in a number of EU countries; with a market share of around 6% in terms of tonnage and 35% for marine equipment**.** Europe is a major player in the global shipbuilding industry, although is facing an international competition from countries like China and South Korea.

Technology and innovation challenges include new transport routes, new transport tasks, economic operation of ships and offshore plants, greening of transport, global liability for accidents, exploration and exploitation of resources in extreme environments, offshore renewable energy production, residential and recreational areas at sea and under the sea, new generation of pleasure craft and many more. In addition, tapping into the digital economy will be crucial to improve safety, protect the environment and meet the expectations of the EU. It is foresee **smart ships** of the future operating in our waters, delivering cargo without delay and at reduced cost to industry and society.

The following target technology areas have been identified for the period between 2015 and 2020 [34]:

- Safer maritime
- Transport through better accident avoidance, more resilient ships and systems, and by improving lifesaving and rescue.
- More efficient and environmentally friendly maritime transport by reducing ship resistance, using cleaner fuels, energy storage and improved propulsion systems as well as advanced energy management to optimize the mix of available power sources and consumers.

A more competitive industry through integration of advanced materials, **automated production**, novel vessel concepts addressing new transport and blue-growthrelated services, a virtual vessel demonstrator and by embracing **big data** in the maritime industry.

The heterogeneous structure of the industry with a comparably high number of companies including many SMEs does not make it easy to create harmonised and focussed strategies.

4.3.7 Secondary target market: Railway

The 2016 edition of the "UNIFE World Rail Market Study" confirms the *positive trends of a growing rail supply industry.* Despite some disparities across the different regions in the world, the attractiveness of rail as a reliable and efficient transport mode has been steadily progressing over the past two years and is forecasted to remain likewise in the future. Over the upcoming six years, the overall industry, with a current market volume of just above EUR 159billion p. a., **is foreseen to grow further at 2.6% CAGR until 2021.** While the largest demand will remain in the interurban segment, the highest growth rates are expected in the urban market driven by growing populations along with expanding metropolitan areas.

Apart from the classic megatrends promoting the development of the rail industry, several new ones have notably emerged in recent years and are expected to contribute to the further growth of the rail

market. The construction of a complete digital ecosystem has provoked new, digital business models to emerge and, with the rest of the industry, benefit from high volumes of data.

From a legislative point of view, significant efforts, through the **EU's Fourth Railway Package** [35], are being undertaken to improve the competitiveness of the European rail system and adapt to the changing transport needs. The adoption of the Fourth Railway Package will have a positive impact on rail supply companies as well as on rail operators by supporting further harmonization of European rail traffic. Moreover, rail has steadily improved its position as the transport means of choice, especially in urban areas: modern rail control technologies, such as unattended train operation and communications-based train control, further improve capacity and safety of rail transport compared to other transport modes. Through its technical and political pillars, the Fourth Railway Package will increase **harmonization** and **liberalization** of the European rail market. The overall goal of the package is to create a fully open domestic passenger transport market by 2019 through the establishment of a single European railway area.

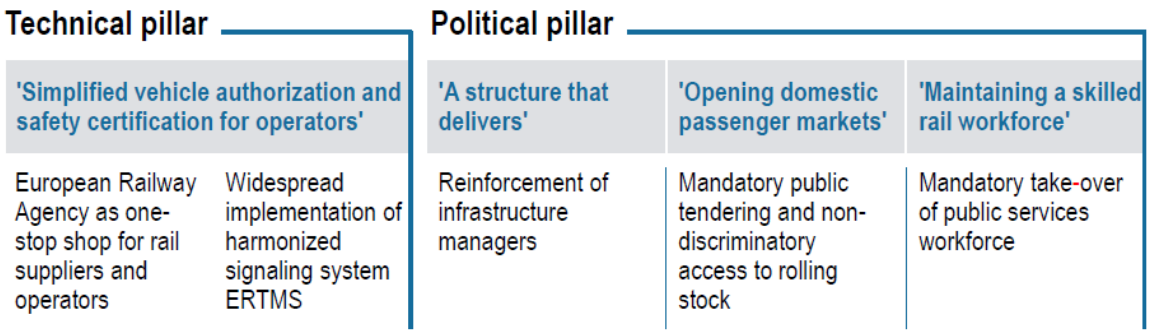


Figure 22 Overview of the European Fourth Railway Package

In addition, Sub-Saharan Africa has become an attractive region for rail suppliers with unprecedented growth rates drawing investors' attention towards business opportunities in the region.

The overall rail supply market has witnessed **a substantial growth at 3%,** driven for the main part by the Asian Pacific region. At over EUR 159 billion, the world rail supply market has reached a record high level. From a product segment perspective, the largest contribution to the market's growth in the 2013 – 2015 period compared to the 2011 – 2013 period stemmed mainly from *the rolling stock* and *services segments*. Added together, these two segments account for 72% of the total rail market in the 2013 – 2015 period. The highest growth rates have been recorded both in the rolling stock and the rail control segments, with 5.8% and 4.9% respectively. In particular, the rolling stock sector benefitted from record-high purchases of locomotives and freight wagons as well as from several large-scale orders in other product segments, such as metros, commuter trains and (very) high speed trains.

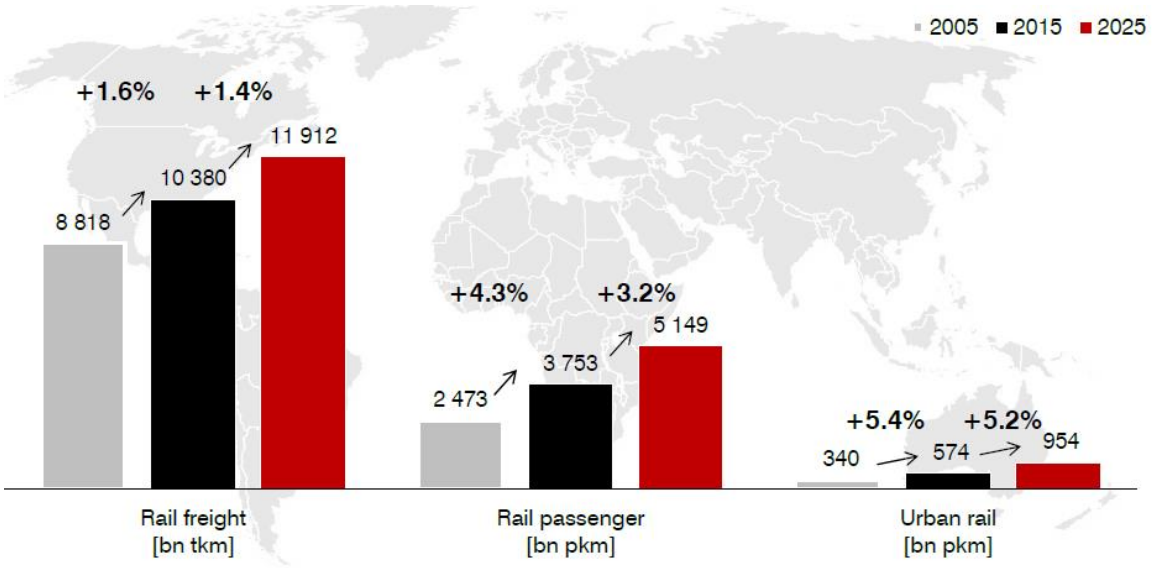


Figure 23 Worldwide rail transport performance and CAGR by the three main segments

The **rail freight segment** has grown less positively in the past five years and it registered an absolute reduction in 2015 for the first time after 2009 [36]. Its development will continue facing challenges in the short term, but it is expected to return to growth in the long run. Rail **passenger transport has shown a constant positive development** over the past years and it is expected to continue growing significantly, although at slightly lower rates. Similarly, **urban rail transport** has registered a constant positive development, but at higher rates. Its **growth is expected to decelerate slightly only after 2020**.

As per UNIFE forecasts, the total market for rail supply is set to continue its growth of recent years at 2.6%. The rail supply market is foreseen to reach approximately EUR 185 billion per year in the 2019 – 2021 period. While the different regional markets are projected to grow steadily in the future, the highest growth rates are expected in **Western Europe and Africa/Middle East, 3.1% and 3.0**% respectively. From a product segment perspective, the highest contribution (in absolute values) to the overall growth is predicted to stem from the services and rolling stock segments that will supply 68% of the expected market growth.

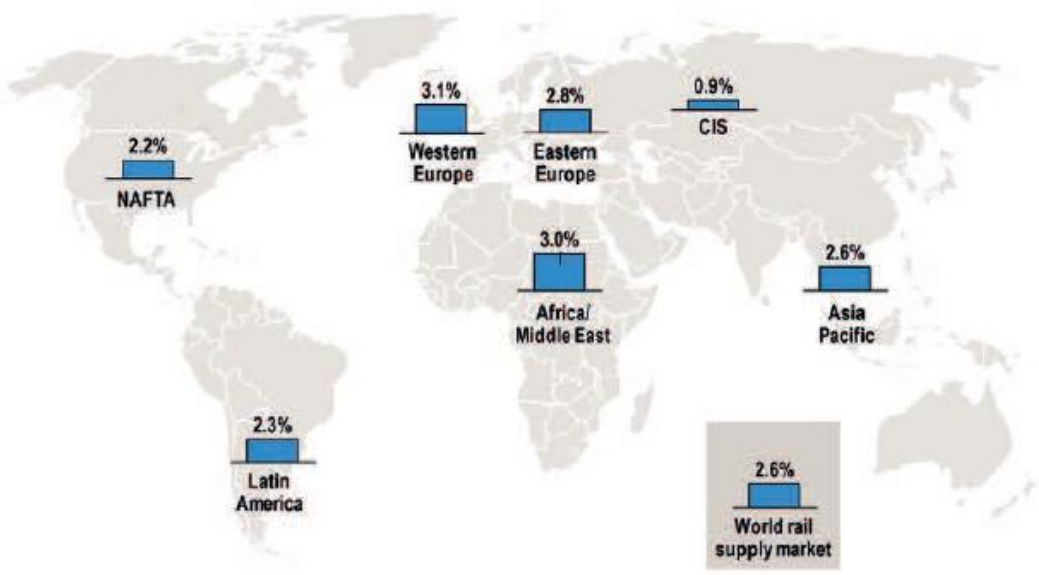


Figure 24 Future developments in the global rail supply market.

France, UK and **Germany** drive the market in Western Europe – Growth expected across all segments (Figure 25): France and UK will invest **significantly in the VHS segment,** contributing to the overall market growth.

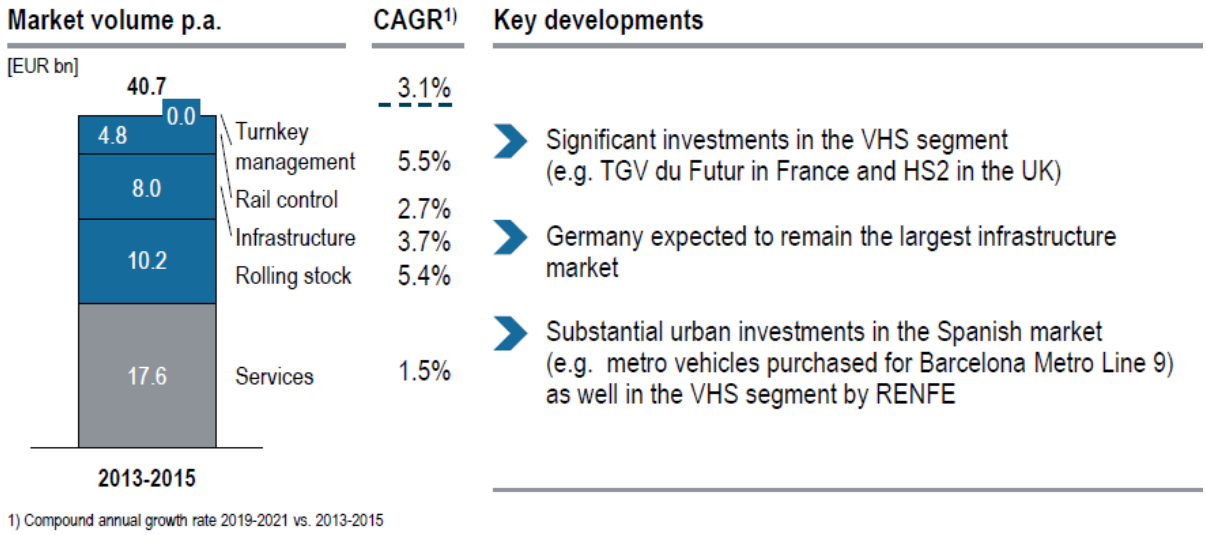


Figure 25 Western Europe –expected CAGR in 2019-2021

Due to **significant investments in VHS and urban** segments, the total market in **NAFTA** will amount to nearly **EUR 34 billion in 2021** (Figure 26)**.**

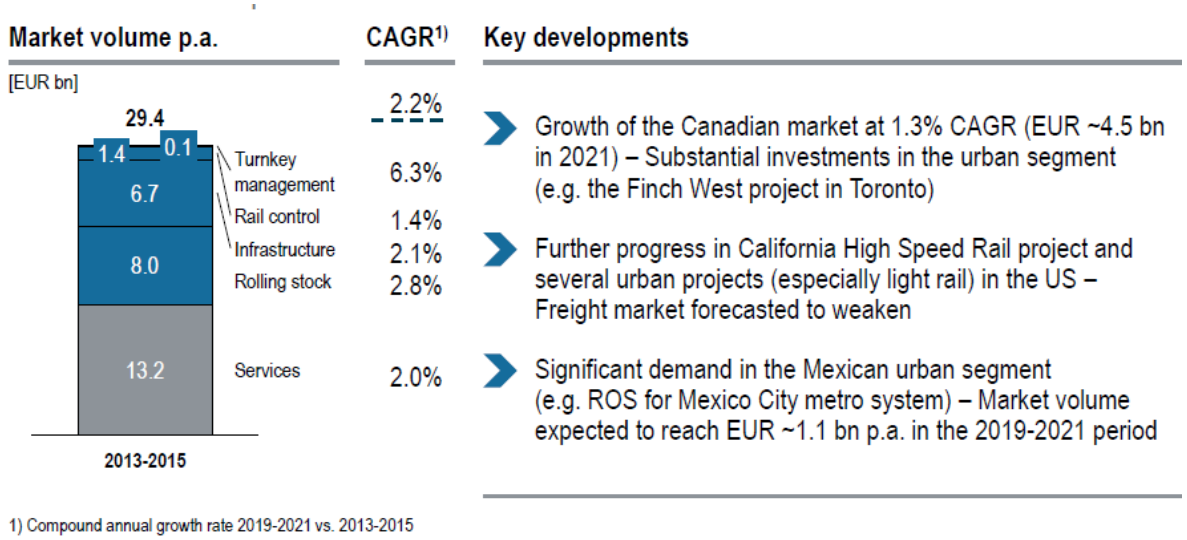


Figure 26 Total market developments in NAFTA

The market in **Asia Pacific** is predicted to show substantial growth in the future **at 2.6% CAGR (**Figure 27**)**.

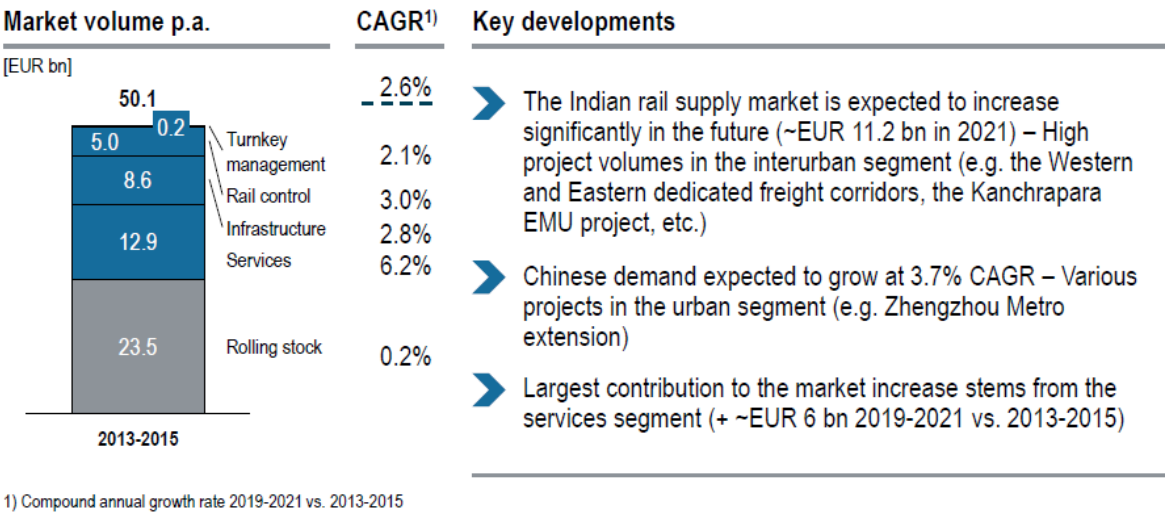


Figure 27 Total market developments in Asia Pacific

The markets in **Africa/Middle East** are expected to **resume growth** in the long run following a short-term decline (Figure 28).

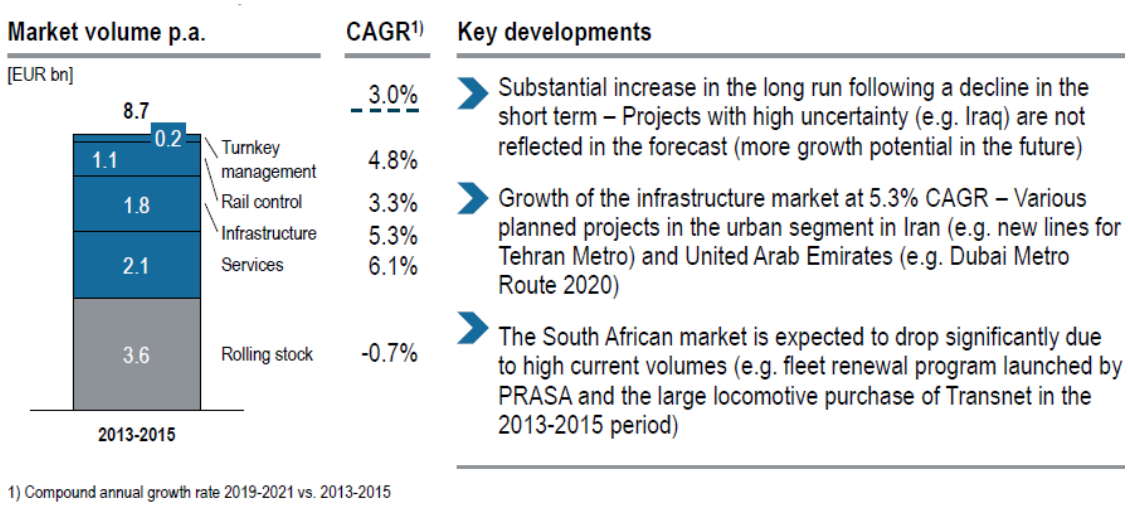


Figure 28 Total market developments in Africa\Middle East

5 SOCIO-ECONOMIC IMPACTS

As EU manufacturing emerges from the recession, its competitive strengths remain intact: highly skilled workers, high domestic content of export goods, and comparative advantages linked to complex and high-quality product segments [37].

The fall in recent years in the value-added share of manufacturing is due mainly to falling relative prices of manufacturing in relation to services, which in turn stem from higher productivity growth. Discounting for the relative price effect, the actual fall has been much more gradual. On the other hand, the positive impact of reindustrialisation on the value-added share may not be strong enough to outweigh the opposite effect of falling relative prices.

Otherwise viable projects appear to be held back by financial markets imperfections.

Smaller and younger firms are especially affected and policy measures to improve their access to external financing may be justified. Smaller and younger firms are also less likely to enter foreign markets. Most internationalisation strategies by SMEs are focused primarily on exports and driven by factors in their home country and in the target country.

The efficiency of public administration has an impact on the growth of firms, both in terms of employment and the share of high-growth firms. There are, however, only weak indications that public administration plays an important role as an input to different sectors of the economy.

Product innovation has a positive and large effect on employment growth in all phases of the business cycle, in both manufacturing and service sectors. The effects of process and organisational innovations on employment growth are smaller and often statistically insignificant. The absolute effect of product innovation is largest in boom periods, which are characterised by high demand. However, in recessions, it plays a very important employment-preserving role.

Electricity and gas prices are higher, and have recently risen more in the EU than a number of other economies, mainly due to rising taxes, levies and network costs.

Econometric analysis shows that, for several manufacturing industries, energy efficiency improvements have not fully offset the negative impact of increasing energy prices, even though European industries have achieved more than international competitors in reducing their energy intensity.

Increasing electricity costs had a negative impact on export competitiveness. The impact can be particularly challenging for certain energy-intensive industries in the EU.

5.1.1 Policies and best approaches for the factories of the future

An efficient public administration is an important driver of competitiveness [38]. It is becoming widely accepted in the EU that efficient public administration (PA) is a key driver of EU competitiveness. The demand for more efficient PA in the Member States has created a need for empirical evidence in addition to ‘business perceptions’, which are currently the only available form of feedback on the link between PA efficiency and business performance. While the need for more efficient PA can be supported empirically, assessing PA efficiency via microeconomic channels, with a view to providing ‘hard evidence’, is much more challenging.

Greater PA efficiency induces higher rates of fast growing firms, in particular by increasing firm turnover and net entry. This holds especially for general indicators that measure the overall governance system, including the presence of an independent judiciary and freedom from corruption. From this perspective, PA efficiency is tied to the quality of a country’s institutions and general (including political) governance.

Public service provision that relies more on fees than on taxes may be associated with higher efficiency. It is becoming widely accepted that efficient EU public administrations (hereinafter PA) is an important driver of the EU's competitiveness.

Throughout their lifecycle, from their market entry to their closure, firms interact frequently with PA on a variety of occasions, e.g. when applying for licenses, paying taxes or engaging in legal disputes. These interactions are costly for firms, which either have their employees dealing with burdensome bureaucratic tasks instead of pursuing productive activities, or have to pay external advisers to do so.

Ultimately, in both cases, internal resources necessary for investment and firms' growth are reduced. The European Commission has stressed the importance of an efficient, effective and transparent PA in the Europe 2020 strategy and has already taken several measures to reduce the costs incurred by firms when dealing with PA. Initiatives in this area involve, among others, the **Small Business Act** [39], **the Services Directive** [40], **the Action Programme for Reducing Administrative Burdens in the European Union** [41]. While the first two initiatives refer to more general targets with respect to PA, the third provides recommendations for particular dimensions of PA. Furthermore, the **Annual Growth Survey 2013** [42] sets out the economic and social priorities for the EU and outlines particular measures for the modernization of the PA in the Member States, in a way that can promote growth. The industrial competitiveness and economic growth currently seem to be hindered by inefficient public administrations, corruption, ineffective justice systems and legal uncertainty in a considerable number of EU Member States.

The EU supports industrial change through its industrial policy and through research and infrastructure funding. In 2012, in response to the decline of the relative contribution of industry to the EU economy, **the European Commission set a target that manufacturing should represent 20% of total value added in the EU by 2020 [43]**. Whilst some observers find this goal overly ambitious revolution, Industry 4.0, which could boost the productivity and value added of European industries and stimulate economic growth. As part of its new Digital Single Market Strategy, the European Commission wants to help all industrial sectors exploit new technologies and manage a transition to a smart, Industry 4.0 industrial system.

Fostering growth and competitiveness and achieving the goals of the Europe 2020 agenda are part of top priority for the EC and EU Member States. European industry will need to capture the potential for productivity and growth that Industry 4.0 appears to offer in order to remain competitive.

The A4BLUE consortium is liaising with European manufacturing organizations in order to promote the project technologies and potentially to find relevant information for the market analysis and exploitation strategy. In particular, A4BLUE has established synergies with these organizations and other EU projects:

- **The European Factories of the Future Research Association (EFFRA**) is a non- for-profit, industry-driven association promoting the development of new and innovative production technologies. MANUFUTURE technology platform and key industrial associations established jointly the EFFRA in order to promote and support the implementation of the 'Factories of the Future' public-private partnership.
- **FOURBYTHREE project** [fourbythree.eu/]: relevant input for A4BLUE is the acquired knowledge related to (1) Modular industrial robotic solutions suitable for efficient task execution in collaboration with humans in a safe way, (2) Automation with collaborative robots that are easy to use and program by the factory worker.
- **ROBOPARTNER project** [www.robo-partner.eu/]: relevant input for A4BLUE is the knowledge related to the safe cooperation of operators with autonomous and adapting robotic systems through a user-friendly interaction.
- **MANMADE project** [www.man-made.eu/]: relevant input for A4BLUE is the human centric taxonomy including worker characterization, factory characterisation and external sustainability context to be taken into account for the Virtual Process Representation.

- **SATISFACTORY project** [www.satisfactory-project.eu/]: relevant inputs for A4BLUE are: (1) the reference implementation and architecture: of the collaborative and augmented-enabled ecosystem for increasing satisfaction and working experience in smart factory environment; (2) the experience in the use of the human-centred design techniques and Human-Machine Interfaces.
- **FACTS4WORKERS project** [facts4workers.eu/]: relevant inputs for A4BLUE are: (1) Modular smart factory infrastructure, a workercentric smart factory solution, satisfying the workers' goals; (2) Novel ways to interact with information and knowledge inside the working environment; (3) Data enrichment and aggregation, including semantics and linked data, analytics, and visualization frameworks.
- **SO-PCPRO project** [www.so-pc-pro.eu/]: relevant inputs for A4BLUE are: (1) Subject oriented workplace design; (2) Empowering workers in assembly lines.
- **OpenMOS project** [https://www.openmos.eu/]: relevant inputs for A4BLUE are: (1) Full economic sustainability of the production systems based on intelligent modular plug-and-produce equipment; (2) Creation of an extendable manufacturing system that permits the easy introduction of new products, work orders and changes in the equipment.

5.1.2 Economic key factors

As the economy emerges slowly from the longest and deepest recession in EU history, it is important to build on the existing strengths of EU manufacturing going forward [44].

First, EU exporters have comparative advantages in a number of manufacturing sectors, including those characterised by high technology intensity, such as pharmaceutical products, and by medium-high technology intensity, such as chemical products, machinery and equipment, motor vehicles and other transport equipment. Similarly, in value added terms, the EU has great advantages in chemical products, machinery and transport equipment, but also in metal products, wood and wood products, paper, printing and recorded media.

Secondly, **the domestic content of EU manufacturing exports is high — around 85 % of value added** — and comparable to the domestic content of Japanese or US manufacturing exports. The domestic content of Chinese and South Korean exports is much lower, as their export goods include much more foreign embedded value added, of which more than 5 % is of EU origin.

Thirdly, **EU manufacturing exports are characterised by a higher degree of sophistication and complexity** than goods exported by many other economies, and from 1995 to 2010 all accession countries of 2004/2007 managed to raise the complexity of their exports.

Fourthly, **EU manufacturing is characterised by a growing share of high skilled workers** carrying out advanced and often specialised tasks. At the same time, many challenges lie ahead and the EU economy is still far from reaching its targets for manufacturing value added, R&D expenditure, gross fixed capital formation and investment in machinery and equipment.

Financial market imperfections may hold back otherwise viable projects: Europe's economic success depends on the competitiveness and growth of European enterprises. Access to external financing is essential for enterprises to invest, innovate and grow. As a consequence of financial market imperfections, caused by *information asymmetries*, 'financing gaps' may limit enterprises' investment and growth options, if viable projects cannot be financed. Since 2008, the proportion of successful bank loan applications has fallen significantly, along with the level of enterprise investment. While the sharp fall in private sector investment is largely a consequence of weak demand, financial market imperfections may have also played a role.

External finance has an effect on the growth of firms by providing resources to support investment, productivity, employment and expansion into international markets. Long-term credit is very important to all firms' moves to take on new staff, but most crucial for domestically-owned small and

medium-sized enterprises (SMEs) and very small (micro) firms seeking to expand their workforce. In general, for young firms there is a strong positive relationship between increased cash flows and total factor productivity.

In terms of enabling new employment, the **high-tech knowledge-intensive services sector** is more reliant on external finance than other sectors. Firms that are less financially constrained are more likely to export, possibly because they have the available funds to overcome the sunk costs of entry into export markets. However, financial constraints do not affect the export sales (intensity) of firms that are already exporting. Access to external finance is more important as a driver of new investment for manufacturing and construction sectors than for services.

Energy cost has a significant impact on industrial competitiveness: Electricity and gas prices have grown more in the EU than in many other economies. Although energy cost shares are slightly less than 5% of gross output in advanced economies such as the EU, Japan and the US, they have been generally increasing over time. For energy-intensive sectors energy cost shares are a fundamental determinant of competitiveness. In terms of energy intensity, a strong convergence process has taken place across major economies, particularly in Europe where Member States have been able to reduce their energy intensities. This has been driven mostly by technology, but a structural shift towards high-tech industries has also played a role, particularly in the EU-12 countries. By contrast, in the EU-15 a structural shift towards chemicals and chemical products has limited the reduction in energy intensity.

End-user gas and electricity prices for industry vary considerably across countries. In the case of natural gas, this reflects the regional fragmentation of wholesale markets, the differences in wholesale gas pricing formulas and varying degrees of end-user price regulation. In the United States, gas prices are largely independent of the oil markets and tend to be much lower. The recent shale gas 'revolution' and the high degree of pass-through have also contributed to keeping industrial prices at around a quarter of the OECD-Europe average. Elsewhere, the cross-country differences in end-user gas prices can be largely attributed to varying degrees of price regulation. In Russia, low gas prices for industry are explained by end-user price regulation and cross-subsidization of domestic customers at the expense of foreign shipments. Gas prices for industry in China vary widely by region, but on average they are broadly in line with the European level. In Japan, gas prices for industry are currently among the highest in the world, due not only to high upstream prices but also to cross-subsidization of households by industry.

Due to taxation and exemptions, electricity prices in the EU differ not only between wholesale and retail but also between sectors and Member States. On average they are currently twice as high as those in the US. Network costs and electricity taxation and levies have contributed significantly to strong electricity price growth in Europe. At the same time, **energy costs have decreased in some Member States thanks to the expansion of renewable energy production,** since the variable costs of renewable electricity are negligibly low. There are also substantial differences across Member States, reflecting differences in the energy generation mix, in taxation and in the allocation of the cost of support for renewables, including the exemptions from such costs for many industrial sectors (Figure 29).

	Energy and supply	Network costs	Taxes and levies	Total Price
Austria	-8.4	28.7	48.1	8.4
Belgium	-13.2	33.0	9.4	4.2
Bulgaria	16.2	42.8	100.0	23.8
Cyprus [1]	38.7	0.9	1.3	30.0
Czech Republic	-14.6	39.5	-8.3	8.3
Denmark	-40.7	81.7	3.0	-2.5
Estonia	32.3	5.0	174.5	30.9
Finland	3.9	24.2	169.2	16.1
Germany	-10.4	3.4	204.2	17.2
Greece [2]	20.9	-7.3	157.4	26.2
Hungary	-17.8	-7.9	158.3	-11.1
Ireland [2]	11.5	-5.1	540.0	8.0
Italy	1.7	18.4	143.0	26.6
Latvia	12.7	60.8	0.0	32.0
Lithuania [1]	6.5	15.4	-91.3	7.3
Luxembourg [3]	2.0	2.3	-2.3	1.9
Malta	15.3	0.0	0.0	13.4
Netherlands	-15.3	32.2	18.4	-1.7
Poland	29.9	-1.2	-15.8	12.9
Portugal	17.5	46.7	30.3	27.6
Romania	-15.6	-17.1	0.0	-16.3
Slovakia	-18.9	22.6	528.6	2.0
Slovenia	-19.7	-6.4	102.9	-12.0
Estonia	-2.6	85.8	24.6	23.9
Sweden	-11.7	34.0	20.0	3.8
UK	9.5	42.5	17.8	17.1

Figure 29 Electricity price developments in the EU countries, 2008-2012, cumulative % change (Eurostat data)

5.1.3 Social factors

One of the key EU2020 goals is to achieve social sustainability and set social impact objectives. A4BLUE is designed to fulfil this strategy via its interdisciplinary team who will work together on research activities that combine engineering and social science for the creation of a workplace manufacturing system with effective integration of humans and intelligent machines to promote production efficiency and satisfaction. A4BLUE will meet the four specific Factories of the Future societal impact objectives as follows:

A. **Increasing human achievements in future European manufacturing systems:** A4BLUE's social science studies will measure important psychological constructs (e.g. cognitive workload) in relation to system attributes to ascertain optimal levels for maximising performance efficiency and satisfaction. These parameters will directly, and iteratively, inform the project's engineering design activities on requirements for human and machine functions. This will ensure that a balanced distribution of tasks and enriched communications between the worker and intelligent technologies / informatics is determined and, ultimately, enhance the worker role and potential for human achievements within future European manufacturing systems.
B. **Creating sustainable, safe and attractive workplaces for 'Europe 2020':** impending demographic challenges are being caused by increases to global populations and mobility, ageing societies, and urbanisation. Manufacturing systems therefore need to accommodate more diverse and transient workforces, and meet the needs of more varying cognitive and physical capabilities. A4BLUE project will identify optimal levels of human and system attributes, leading to the creation of workplaces that are more attractive, rewarding and safe for people to work in, as ergonomics, satisfaction and system interactions will be enhanced. As the studies within WP3 will be conducted across a range of predetermined target groups (age, gender, skill and ability) this means that all of the system design, safety assessment and training needs evaluations will account for workforce diversity.

C. **The A4BLUE solution empowers rather than replace people**, improving productivity and work experience and making workplaces more flexible and appealing to new generations of workers, such as the Millennials. Workers will be support and challenge to be creative and more involved in areas that were typically off-limits to prior generations of factory floor employees, such as product and plant efficiency improvements.

The aforementioned impacts will be achieved in a first stage by implementing A4BLUE results on the experimental business cases in AIRBUS and CESA, by improving their operations efficiency and workers satisfaction.

Potential barriers, obstacles and framework conditions have been assessed through the PEST (political, economic, social and technological) methodology, table 6.

P-POLITICAL	E-ECONOMICAL FACTORS
• A major awareness of Governments is required to bring them up to implications at social level such as data security, workplace, health and safety (Privacy and Security). These type of solutions capture and manage person-sensitive digital data. Privacy may be an issue as soon as any data is managed. There's a raising concerns about privacy issues and ownership, as data have nowadays value and companies from many sectors of activity are willing to use them.	• A4BLUE depends on a large number of systemic economic factors. Barriers to the internal market and the weak presence of macro-clusters with different public and private stakeholders that would enable working on common solutions to new needs on a European scale, all hinder the development of innovative adaptive automation solutions. • Another important financial barrier such as the upfront costs of implementing A4BLUE manufacturing technologies will be considered.
S-SOCIAL FACTORS	**T-TECHNOLOGICAL FACTORS**
• **Culture**. Employee need to understand how automation will positively change production processes and job market, generating safer and high skilled job opportunities. A user perspective dissemination approach will be taken into account since a lack of confidence may hamper acceptance. • **Ethical issues**. The design and application of new technologies that affect and interact with humans need careful consideration of ethical issues: A4BLUE will review and adhere to key ethical guidelines and standards that exist or will emerge and be developed in response to technological advances (e.g. BS 8611 Robots and robotic devices guide to the ethical design and application of robots and robotic systems).	• **Lack of interoperability between business systems creates inefficiencies**. Information Technology systems cannot communicate and exchange data and information, manual processes must be employed. This can, in turn, be a source of errors and waste of time. Standards for data exchange and communication at the business and technical level would allow companies to collaborating while still protecting intellectual property. • **Technology acceptance by the workers** lacks the confidence on the solutions for supporting different operations. Training activities should demonstrate how workers can be supported in a reliable way in their daily work without the paper based instructions.

Table 6 PEST methodology

Innovation can have different, contrasting effects on social factors and employment: it can create jobs by creating additional demand for new products, but it can also destroy jobs because of productivity effects and lower demand for old products. It is likely that the extent to which innovation can stimulate demand and the extent to which process innovations are used to reduce costs vary over the course of the business cycle, with important implications for employment.

The results of econometric estimations from **Eurostat** suggest that **product innovation has a positive and large effect on employment growth in all phases of the business cycle, in both manufacturing and service sectors**. In most cases, a 1% increase in successful product innovation leads to a 1% gross increase in employment. The effects of process and organizational innovation on employment growth are smaller and often statistically insignificant. The contribution of product innovation to employment growth is largest during boom periods, when favorable economic conditions lead to higher sales of new products. However, in recessions, product innovation plays a very important employment-preserving role. Employment losses of product innovators are much smaller than those of firms that did not introduce product innovations.

EU manufacturing production followed a very different trajectory in the run-up to the financial crisis and the ensuing recession. After a lackluster start to the century, output expanded for several years until reaching a peak in early 2008. It then fell rapidly by some 20 % as the recession took hold. From its lowest point in 2009, it has since regained almost half the ground lost since 2008. **It is important to emphasize that, though still far from its peak, EU manufacturing output is now higher than at any point prior to the 2005–2008 expansion** depicted in Figure 30.

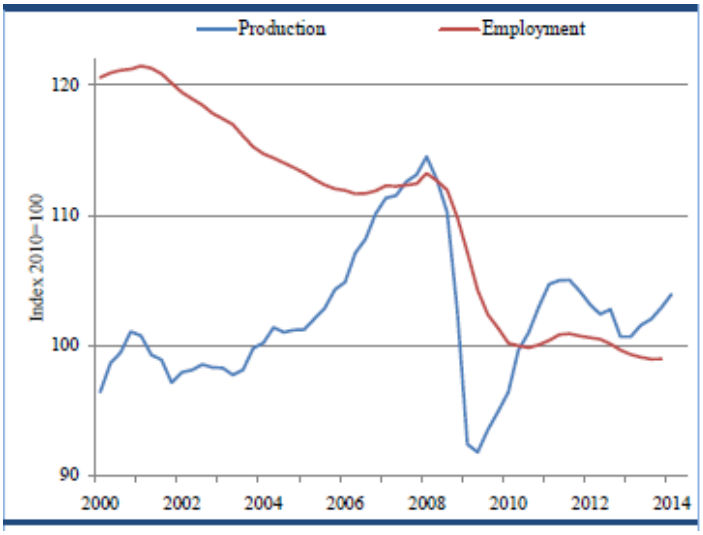


Figure 30 Production and employment in EU manufacturing, 2000-2014

The effects of innovation on employment growth have been the focus of intense debate in economic literature. Different forms of innovation may have different effects on employment and disentangling and quantifying them is a challenging task.

6 COMPLIANCE WITH REGULATIONS AND STANDARDS

Standards allow faster uptake of innovative solutions and enhance the economic value of research projects, facilitating the application of the outcomes in practice and thus fostering the innovation uprising from the research results. Contribution to standardization foreseen in A4BLUE intends to contribute to the awareness, acceptance, replicability and usability of the project results. Furthermore, standardization system constitutes an efficient and fast information and knowledge transfer structure. The bidirectional implication of correspondent technical committees at international, European and national levels allows any information provided to reach an immediate widespread dissemination. In addition, this dissemination is focused to the interested stakeholders in every country, providing a high and mean visibility to the project itself and its outcomes.

A second aspect of the contribution of standardization to the impact of the project and the project results is to be considered at a **longer term**: *if the results of the project are included in future standards, they will be available and ready for use to all the potential users in the European market*.

During the first stages of the project, a review on regulations and standards has been performed. Laws set out general rules of policy that typically do not include any technical specification that can be applied to specific design cases, whereas standards do provide practical and subject-specific technical specifications that are *directly based on laws.* For most technical aspects of the A4BLUE systems, standards will be the most relevant and accessible information regarding requirements to be compliant with. However, for the management of personal data A4BLUE is keen to maintain direct observation of privacy and security laws given that the new systems will capture and apply human data in new ways for the adaptive control, self-optimisation and personalisation functions. The regulations and standards that are observed by the A4BLUE project are collected in the published project deliverables "D1.1 Requirements book and human factors best practice guidance - Initial Version" and "D7.3 Report on the standardization landscape and applicable standards".

A4BLUE solution intends to create new adaptive workplaces, specifically for assembly with very small production series, represented by sectors as aeronautics, capital goods, wind power, shipbuilding, electric vehicles or certain cases in automotive. For the adoption of the A4BLUE solution by these specific sectors, some of **the most critical aspects to be considered are safety of machinery and interoperability.**

A4BLUE aims at introducing flexible automation in the target market. In the new conceived adaptive workplaces, **safety** is the most critical aspect to guarantee for a successful deployment of the A4BLUE solution which includes automation mechanisms and equipment, specifically industrial and collaborative robots. **The safety of machinery and robots standards adopted for such solution will be of obligatory compliance in the target market scenarios.**

On the other hand, A4BLUE proposes a connected workplace where **interoperability** becomes a critical aspect. Compliance with interoperability standards such as **OPC UA** [45] will be required for the deployment of the solution. OPC UA, which is used as the basis for the plug-and-produce feature for seamless integration with automation mechanisms and legacy systems, is a widely accepted standard in the market, and also promoted by the Industry 4.0 paradigm, and therefore is a valuable factor to enter new markets.

7 CONCLUSIONS

A4BLUE project proposes the development and evaluation of a new generation of sustainable, adaptive workplaces dealing with the evolving requirements of manufacturing processes, and the introduction of automation mechanisms that are suitable for flexible and efficient task execution in interaction with human workers by optimizing human variability through personalized and context aware assistance capabilities as well as advanced human-machine interfaces.

The **preliminary market analysis identifies end users and competitive advantage for each of the project results as well as** covers the market opportunity and demonstrates that there is a viable market for the A4BLUE solutions. The steps followed to analyse these markets are: Identification of the main market; Market Size and Trends; Market Structure and Location; Competitive Positioning and Advantage; A4BLUE targeted users; Target Market Segments.

The **manufacturing for the aerospace industry**, driven by the use cases AIRBUS and CESA (Defined in Task 1.2 "Use case scenarios definition"), is the main market sector of reference. **Aeronautics** is a strategic industry in the EU. 2014 turnover level represents 140.5 billion euro employing 534,621 workers, 35% in production activities. Following multiple years of positive growth, the sector revenues will likely grow by **about 2.0% in 2017**. The aerospace supply chain is expected to continue its transformation to reduce costs, respond quicker and to invest more in product innovation; placing a real opportunity for A4BLUE results.

Although the project is instantiated in two real industrial scenarios from the aerospace sector, the concepts, methodologies and proposed solutions can be considered suitable for other processes and sectors such as top class **automotive, electric vehicles, shipbuilding, wind power, capital goods** (machine tool, engines, compressors, etc.) where the problematic is similar: *assembly of big complex products with low scale production and several manual operations due to the high flexibility requirements*. These secondary markets have different growth forecasts:

- *Electric Vehicles* - the global stock of EVs reached 1 million during 2015 and passed the 2 million mark in 2016. This rapid rise has been led by China, the US, Japan and several European countries. The global electric high performance vehicle market is expected to grow at a CAGR of **72.67%** during 2014-2019.
- *Automotive* - global luxury and super luxury car market has seen been relatively untouched by the financial crisis and has been posting growth driven by the emerging markets. According to JATO statistics there's a **+15.9% increase** on 2015 with demand fueled by China in particular.
- *Wind power* - Over the upcoming six years, the overall industry, with a current market volume of just above EUR 159billion p. a., is foreseen to grow further at **2.6% CAGR** until 2021.
- *Shipbuilding and capital goods* - a modest recovery in revenues and operating profit in 2017, as well as a slight improvement of credit metrics from 2016 levels is being expected, influenced by the partial recovery of commodity prices and macroeconomic environment. This positive effect is most pronounced in the U.S. compared with EMEA and APAC.

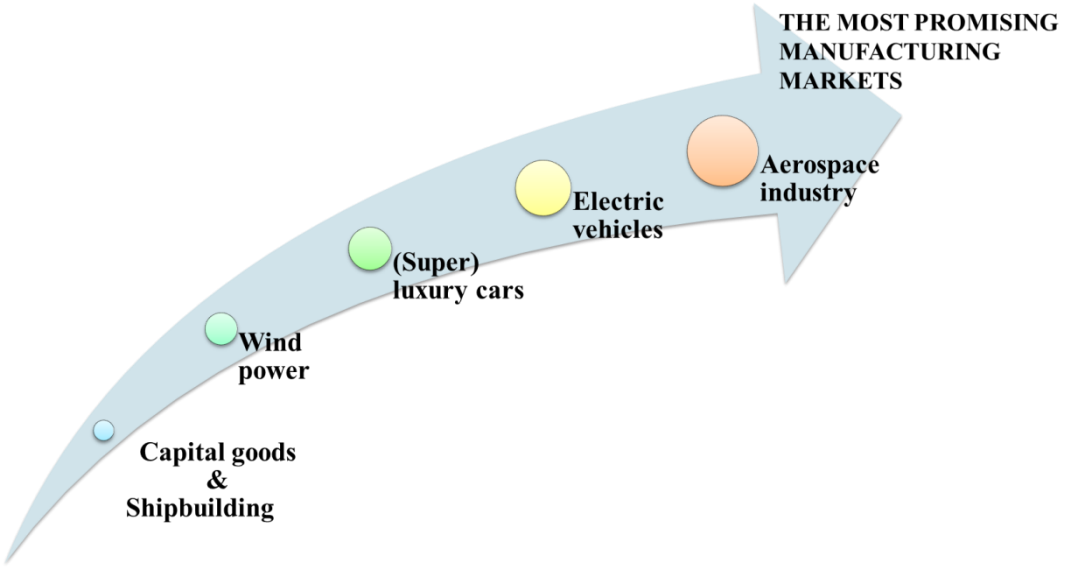


Figure 31 The most promising manufacturing markets for the A4BLUE exploitable results

Finally, PEST (political, economic, social and technological) assessment methodology, which gives an overview of the different macro-environmental factors to be taken into consideration, has concluded with:

- Employees need to understand how automation will positively change production processes and job market, generating safer and high skilled job opportunities.
- Potential economic barriers to implement A4BLUE solutions should be taken into account even when A4BLUE partners define different business models strategies to lead results to the market
- There's a raising concern about privacy issues and ownership that must be solved.
- The key role of standards. Regulations and standards allow faster uptake of innovative solutions and enhance the economic value of research projects, facilitating the application of the outcomes in practice and thus fostering the innovation uprising from the research results. Contribution to standardization foreseen in A4BLUE intends to contribute to the awareness, acceptance, replicability and usability of the project results.

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